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THE SCIENTIFIC MONTHLY

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EDITED BY

J. McKEEN CATTELL

VOLUME IV

JANUARY TO JUNE, 1917

NEW YORK
THE SCIENCE PRESS
1917

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

ol. 4, No. 1 JANUARY, 1917

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: SUB-STATION 84

SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION, $3.00

THE SCIENTIFIC
MONTHLY

JANUARY, 1917

ADVENTURES OF A WATERMOL

A Romance of the Air, the Earth and the Sea

By Professor H. L. FAIRCHILD
University of Rochester

Prelude

I AM only a tiny molecule of water, and so very small that no eye has ever seen me, not even with the strongest microscope. Yet I am an actual thing of real substance. Of such as I are all the clouds and rain composed, all the rivers and riverlets, all the seas and lakes, and the whole of the vast ocean. Nearly all the substance of plant and animal bodies is built of us watermols. We are found in nearly everything, even in the minerals and solid rocks of the globe. And I am very, very old. I have been around the world many times and have had a wonderful history.

You wish to hear the story of my life?

It is a long, long story, for my birth was far back in the old earth's early time. To relate in detail the story of my adventures would be too long for you, poor creature of less than a century of life, even could I

N. R. Graves, photo.

Fig. 1. Merely a few Watermols.

Courtesy of Eastman Kodak Co.
FIG. 2. BIRTH OF WATERMOLS.

take the time from my duty as a globe-wanderer. I can tell you only a few of the strange and romantic events in the life history of a watermol who has been in active duty and a part of the earth's history for a hundred million years. Some of my adventures are so strange that you might doubt my truth, but I could not tell untruth, for I am a part of the reality and verity of the universe.

BIRTH, IN A VOLCANO

There was a time when I, as a watermol, did not exist. I had a creation, a sort of birth, far back in ancient geologic time, scores of millions of years ago. My birth was in a singular manner and under remarkable conditions. It took place deep in the hot chimney of an ancient volcano. Not of any volcano now existing, as it happened long before any volcanic mountains that are now standing were formed.

Not like any organic being was I born, that is, as a little fragment or cell of the mother animal or plant. I was created by the union of three distinct individual particles. Two atoms of hydrogen and one of oxygen united to produce *me*.

I am a composite being, a chemical creation; the child of wedded matter and energy; I am a tiny sample of the infinite cosmos.

These three atoms, or units, had existed from the eternity of the past, and their history is infinitely longer than mine. and it must have been remarkable. If we knew their history we might have a clue to the

origin of the sun and of the vicissitudes of stars and nebulæ. They must have been in the nebular matter or cosmic dust that formed the sun, and in the evolution of the solar system they became attached to the earth. If they had any choice in the matter we may suppose that the earth offered some peculiar attraction. Perhaps they foresaw the strange phenomena called life. These tiny atoms helped to build the earth, for in some material they fell on the surface of the growing planet when the globe was not half its present size. At the time of my creation the three atoms lay close together in the very hot stuff or lava down in the pipe or chimney of the volcano. Under the intense pressure and heat at great depth in the earth such atoms could not unite, but with the lower temperature in the tube of the volcano they were able to lock arms and blend together into one body—and here am I, the result.

At the time when I was created I was only one of the countless millions of millions of water molecules all made in the same way. We were very hot and packed close together under great pressure. As we all worked our way upward in the tube of the volcano we were finally able to overcome the compression, and suddenly we drew apart and produced an instant expansion or steam explosion which blew the top of the volcanic mountain into pieces, and forced a huge column of water vapor to a height of miles in the atmosphere. Most of the water on the earth's surface, including the ocean, was probably formed in this manner.

I was one of the particles of invisible water, or steam, that wrecked the mountain; and I found myself, a new creation, a distinct, complex being, high up in the rare atmosphere.

By the volcanic explosion and the heated air current I was carried

I. P. Bishop, photo.

FIG. 3. WATERMOLS IN AERIAL JOURNEY.

FIG. 4. WATERMOLS IN HASTE.

FIRST EXPERIENCE IN THE AIR

up high into the atmosphere. Of course I did not measure the height, for I had no measuring stick, but I guess it was about ten miles. I was held up, as a separate watermol, in the grasp of the molecules of nitrogen and oxygen which chiefly compose the mass of the gas envelope surrounding the earth, and called the atmosphere. All about were endless millions of other watermols, flying swiftly back and forth as they collided with each other and with the air molecules. What the purpose or reason was I do not know. Really, what is the purpose of anything?

It was a free life, miles up in the sky. We were carried swiftly eastward in the great wind currents that at high altitude always sweep around the globe from west to east. Along with the multitudes of my fellow watermols, and also molecules of other kinds, and dust particles, I circled the globe.

It was a joyous life. The air was thin or rare and we watermols were not closely confined in our captivity, but were permitted to move rapidly back and forth, for molecules are very restless, fidgety things. We were always hitting each other and bounding back and forth in all directions, many millions of times a second, because of our high elasticity. In scientific language this is called molecular vibration.

We were above all the clouds and storms, as these belong only in the lower strata of the atmosphere. At that great height the sky above was black, the sun was blue and the stars could be seen at midday. The density of the air at the height of ten miles is only about one tenth as great as at the earth's surface, and one half of all the mass of the atmosphere is within three and one half miles from the ground. At

that height in the thin air the sun was terribly hot but the air temperature was far below freezing, for the sun's heat rays pierced right through the air without warming it. But all this made no difference to me, for to a separate molecule there is no such thing as temperature, heat being an effect of the movement or vibration of molecules when many are crowded close together.

In a Cloud

After traveling a long time in the upper air some change took place in that part of the atmosphere which held us captive, and thousands of us watermols were allowed to attach ourselves to a little mote of dust or solid particle. We now formed a tiny mass of solid water, an ice crystal, but yet so small that we floated in the thin upper air. Myriads of other water crystals also formed, and together we made a little cloud, floating high in the heavens.

This time was long before man appeared on the earth and even before any air-breathing animals lived. If the animals in the sea which had eyes could look up in the sky they might have seen us as a little fleecy, cirrus cloud floating idly in the blue dome.

Sometimes the air molecules crowded closer together about our ice crystal and pulled us watermols apart, and we were again separate or free, and the wispy cloud vanished. At such times the temperature had risen and the ice crystals had evaporated, or, in other words, the cloud had dissolved in the air. Such changes occurred many times. Finally, at a time when we were lower in the air, and all the molecules of every kind were close and in rapid vibration, which means that the temperature was higher, we watermols were allowed to cling to a dust particle so as to make a tiny sphere of fluid water. The myriads of water spheres together formed a little cloud, just as the ice crystals had done at higher and colder altitudes. Our cloud of

N. R. Graves, photo.

Fig. 5. Watermols Traveling at Leisure.

FIG. 6. WATERMOLS FROZEN AND NEAR FROZEN.

water spheres grew by adding more watermols until it was a great, dark cloud, overspreading the sky and shutting off the sunlight from a space on the ground beneath. Two mysterious forces were acting on our water spheres. Each force was a pull and a push. One force, called gravitation, tended to draw the little spheres together to make larger spheres, while the other force, called electric repulsion, tried to drive

FIG. 7. WATERMOLS ENJOYING A HOT TIME.

them farther apart. Finally the electric force or the pull-apart, or push-apart, became weaker, or may be the push-together became stronger, and the tiny water particles united into larger spheres. These larger water drops were too big and heavy to float freely in the air, and they slowly fell through the air and dropped as rain in the sea. And now my individuality as a watermol was drowned in the mass of water of the limitless ocean.

IN THE OCEAN

This was a great change from the life of a free watermol, invisibly floating high up in clear sky, or even as part of a tiny ice crystal or a water sphere in a cloud. Now I was only an insignificant molecule of

water in the vast ocean. Of course I was of just as much consequence and use as any other watermol, but there were so many of us! A tiny drop of water on the point of a pin contains millions.

In the air I had been a prisoner, being held in the grasp of the air substance. Now I had to help hold other substances captive. We watermols of the sea kept as prisoners, or in solution, many kinds of molecules. There were so many kinds with such long names that it is difficult to name them. The most numerous prisoners were the molecules of chloride of sodium, commonly called salt. Next was chloride of magnesium. Then there were sulfates of magnesium, calcium and potassium, and carbonates and bromides and iodides and fluorides, even

FIG. 8. WATERMOLS CARRYING ELECTRIC CHARGES.

silver and gold, and, Oh! too many others to try to name. Just as the air molecules, as a gas, had held us watermols captive, so now we watermols as a fluid held solid substances captive, or in solution. We had a little revenge on the air, for we had as captives some molecules of nitrogen and oxygen.

In the mass of water we were tumbled about by the winds, as waves or swept along as currents or ocean rivers. There was also movement or circulation due to differences in weight and pressure produced by difference of temperature. So I was sometimes dashed against the shores of ancient continent or swept from the equator to the pole, or perhaps clear around the globe.

When we watermols were at the surface of the sea the molecules of the air would take hold of us and try to carry us away as captives. In the sunny days billions of my fellows were coaxed off into the warm air, and at last this was my fate, or good luck. I was pulled away from the

sea and lifted high into the atmosphere. Again I was in the clear sky, a care-free watermol with nothing to do but float around and look down on land and sea.

In a Glacier and Iceberg

After a long time and much journeying, sometimes as a free watermol, sometimes in vapor cloud and sometimes in frost cloud, I was

W. A. Bentley, photo.

Fig. 9. Watermols Playing Leapfrog.

again built into a tiny frost crystal, a little three-sided prism of clear, transparent ice. Floating high in the cold air our ice crystals bent the rays of sunlight and made the rings of brightness and color about the sun and moon, the halos and coronas. At last my ice crystal grew out into a beautiful six-angled snowflake; and this became part of a snow cloud. Then the cloud floated over a great mountain range in some ancient land, unknown to me, and my snowflake was added to the

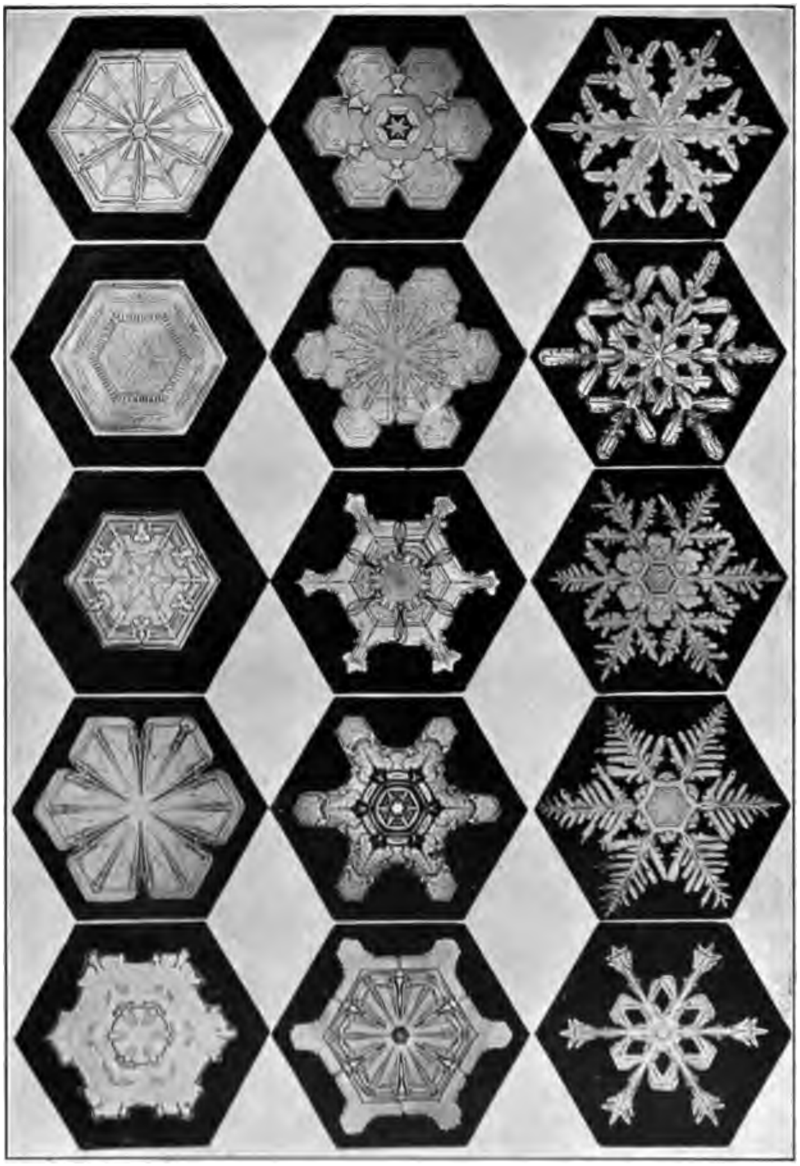

FIG. 10. WATERMOLS AS FALLING STARS.

FIG. 11. WATERMOLS AS SNOWFIELD AND GLACIER.

vast snow field on the mountain height. Other storms piled more snow over us, and so I was buried in the broad, deep snow cap.

This was pretty cold for me, who had been in the warmth of the tropic seas. But worse was yet to come, for other snowfalls buried me deeper and yet deeper in the snow mass. And then the mass of which I was a tiny part began to move slowly down the mountain slope. After some centuries the movement and the pressure compressed the snow into solid ice, and now I was in a solid, cold, transparent ice body. I was part of a glacier on some old continent in some very ancient time.

Surely, this was a great change from the careless life of a gaseous watermol in the atmosphere; or even as a part of the liquid ocean. Now I was part of a solid. And I was grasped so closely and rigidly by my icy fellow mols, all in regular crystallized ranks, that there was little chance for the vibration which is the nature of all molecules. In the air I had freedom of motion, and some chance even in the water, but now I was in a cold, close prison for ages and ages. No light, no play, not even work, but just darkness and crushing stillness! It was frozen silence.

Slowly, very slowly, I was carried along in the creeping glacier, until after what seemed endless time, I was near the end of the great ice flow and thought my freedom was near. But it was a false hope, for the part of the glacier in which I was imbedded was pushed out into the ocean. The up and down motion of the tides loosened the ice mass and it broke off and floated away in the sea as an iceberg. So I was yet in the cold prison, which drifted about in icy waters for many tedious years. But finally the iceberg broke up and went to pieces and melted away. At last I was again in the fluid water of the briny ocean.

(To be continued)

FIG. 6. WATERMOLS FROZEN AND NEAR FROZEN.

air-breathing vertebrates is as follows: The geologic evidence on the nature of the physical environment in Silurian and Devonian times, combined with the fossil record and supplemented by the archaic vertebrates which still linger in life, indicates that recurrent epochs of semi-aridity brought conditions of severe repression upon river fishes. As the dry season advanced the rivers were reduced in flow, the content of oxygen decreased and the extreme restrictive conditions were represented by isolated pools, stagnant and foul from the decomposition of animal and plant remains. The piscine fauna which endured these conditions came through profoundly changed. The primitive sharks found earlier in fresh-water deposits, having no air-bladder, were driven to the seas. The fresh-water fishes which remained were ganoids and dipnoans, fishes with air-bladders efficient for the direct use of air. Finally, from crossopterygian ganoids, under the stimulus of the semi-aridity of the Devonian, there emerged the amphibians; able to carry forward their activities as terrestrial animals. This was a major step in the remote evolution of man.

Did a similar climatic change in the Tertiary period acting on a species of large-brained and progressive anthropoid apes isolated from the regions of continued forest compel them to adapt themselves to a terrestrial life or die? Did the gradual dwindling, leading even to the extermination of forests, in a region from which the forest fauna could not escape, produce a rigorous natural selection which transformed an ape, largely arboreal and frugivorous in habits, into a powerful, terrestrial, bipedal primate, largely carnivorous in habit, banding together in the struggle for existence and by that means achieving success in chase and war? The gradual elimination, first of the food of the forests, lastly of the refuge of the trees, through increasing semi-aridity, would have been a compelling cause as mandatory as the semi-aridity which compelled the emergence of vertebrates from the waters, transforming fishes into amphibians; the first of the vertebrate rulers of the land.

It is the purpose of the present article to assemble the evidence which suggests this climatic cause acting upon our simian ancestors as a controlling factor in this latest of the major stages in human evolution. It falls into accord with the general conclusion of Matthew that "the evolution of land life in adaptation to recurrent periods of aridity supplies a satisfactory background of cause for the whole evolution of the higher vertebrates."[2] The writer also has had the advantage of discussing this subject with Professor R. S. Lull, whose large knowledge of the organic side of these problems has served as a source of reference and has been in many ways of special value.

[2] W. D. Matthew, "Climate and Evolution," *Annals of the New York Academy of Sciences*, Vol. XXIV., 1915, pp. 171–318 (p. 181).

The significance of evidence depends largely upon the hypotheses which control its interpretation. For that reason, before taking up the facts which bear directly upon the adaptation of man to a terrestrial habitat, there should be considered the general relationship of environment to evolution.

The changes in successive faunas prove that internal factors modify the strains of heredity and that new species thereby become established, even though there are at present large differences of opinion in regard to the mode of operation of those internal factors. On the other hand, the general adjustments of organisms to environment, as marked by their efficiency in meeting the conditions around them, prove also that evolution is correlated and conditioned in some way with environment. There is then a complex of actions, interactions, and reactions, both within and without the organism; such as Osborn has emphasized.[3] Nevertheless, in the complex of actions and reactions which accompany organic progress, there must be in each step some leading cause; the others follow. The evidence from the geologic record, when combined with the biologic evidence derived from the study of living organisms, seems to show that the great upward steps in evolution are primarily determined by environmental changes which operate to diminish the quantity of life and work toward the extinction of ancient types.

On the other hand, in the splitting of a family into various subfamilies, genera and species, the leading rôle would seem to be taken by a tendency toward organic change, the environment remaining in the meantime nearly constant. The tendency to organic change—variation, mutation, or whatever it may prove to be—is apparently often manifested, when once started, by a progression in one direction, indicating the acquisition of an evolutionary momentum known as orthogenesis. The lines of orthogenetic progress must not transgress flagrantly, however, the limits of efficiency; since in that event natural selection will begin to operate and terminate the line. That environment and natural selection are not the initial or controlling causes in such orthogenetic changes is suggested by the fact that differences arise which are immaterial to the environment and in many cases progress considerably beyond the limits of efficiency before the law of the survival of the fittest emerges into operation.

Naturalists have often in their mental pictures simplified nature too much and made a single cause too inclusive in its action. They have often also not given heed to the indications that different kinds of evolution have been due to a different category in the controlling cause. The early advocates of the doctrine of descent made everything dependent upon the influence of natural selection as the mainspring of

[3] H. F. Osborn, "The Origin and Evolution of Life Upon the Earth," THE SCIENTIFIC MONTHLY, p. 10, July, 1916.

evolution. On the other hand, it would appear that many who have studied modern organisms, but who have not weighed fully the geologic evidence, have been too sweeping in their conclusions that the Darwinian explanation of the mode of evolution must be more or less wholly supplanted by some other mode. To state or imply, as some students of Mendelianism have done, that the evolution from protozoan to higher metazoan has been determined by the mere continued dropping away of inhibiting factors seems an extremely narrow and partial view, overlooking causes, and mistaking mere mechanistic modes of internal reaction for the whole of a complex series of actions, interactions and reactions.

Bearing in mind this cooperation of various factors in organic evolution, let us turn to that last great step in human evolution, the transformation of the arboreal ape to a ground-dwelling ape-man, maintaining himself in contest with the powerful foes which were previously rulers of the ground. We must note first that most evolutionary studies deal primarily with the anatomical characters and phylogenetic relationships. In so far as the environmental setting of the evolutionary changes is concerned, the tropical forests of southeastern Asia have been favored as the original home of man. The discussion of the causes of this evolution have generally been secondary, the conventional hypothesis holding that a tropical man-ape in the forests of southeastern Asia left the sheltering trees simply because he had advanced to a certain stage where, like a child grown up, he had the ambition and found the ability to go forth and conquer a different world from that of the adolescence of his race. The alternative hypothesis which will be set forth here is, specifically, that the compulsion of increasing aridity in Miocene times, by isolating anthropoids north of the Asiatic mountain systems and reducing the forests there to savannahs and open plains, was the primary cause in the differentiation of the ape-man from the apes and thus was fundamental in the initiation of human evolution. This hypothesis is in accord with the views of Matthew in regard to the conditions surrounding the center of dispersal of man. Matthew has stated:

In view of the data obtainable from historical record, from tradition, from the present geographical distribution of higher and lower races of men, from the physical and physiological adaptation of all and especially of the higher races, it seems fair to conclude that the center of dispersal of mankind in prehistoric times was central Asia north of the great Himalayan ranges, and that when by progressive aridity that region became desert it was transferred to the regions bordering it to the east, south and west. We may further assume that the environment in which man primarily evolved was not a moist or tropical climate, but a temperate and more or less arid one, progressively cold and dry during the course of his evolution. In this region and under these conditions, the race first

attained a dominance which enabled it to spread out in successive waves of migration to the most remote parts of the earth.[4]

To present the data on which the present hypothesis rests, let us examine the geologic and climatic changes over Asia during the Tertiary period.

In the Eocene the ancient Mediterranean of Tethys still existed as a shallow sea stretching through Eurasia along the belt of the present Alpine-Himalayan mountain systems. As shown by both floral and faunal evidence, warm and moist climates prevailed over the earth, outside of the tracts of tropic deserts determined by the planetary winds. Some variation of climates is evident, as shown, for instance, by glacial deposits in the early Tertiary of Colorado, but, especially during the middle and later Eocene, subtropical forests existed widely over the north-temperate zone.

Similar climatic conditions characterized the Oligocene, a warm temperate flora occurring in Greenland and palms in the region of the Baltic; but on the whole the climates were somewhat cooler than in the Eocene and more variable. The flora indicates a lessening of humidity and a clearer differentiation of the seasons. The first movements of uplift began to be felt in the Pyrenees and along the Alpine trough.

The Miocene was marked by a great crust movement which separates the younger from the older Tertiary. The floor of Tethys was now compressed, the shallow sea displaced, subsidence gave place to uplift, and the greatest mountain system of the globe began to grow through vast repeated movements in the crust. The continents also were elevated and widened, connections established, and intermigrations of previously isolated faunas took place. The forest-dwelling types became restricted, largely exterminated, and animals of the plains in the form of horses, rhinoceroses and the cloven-footed mammals greatly expanded in numbers and in species. This profound faunal change implies drier climates and is in harmony with the implications of the growing mountains. There was now a lesser area of tropic seas to give moisture to the atmosphere. The mountains were now effective barriers shutting off the moisture-bearing winds from the interior of the continents. Marine invertebrate faunas indicate cooler and more zonal climates, a result, perhaps, of a less free oceanic circulation.

These climatic effects in the Miocene were moderate in amount so far as the chilling was concerned, with the result that a great expansion of mammalian life took place and it was not until the close of the Pliocene that animals of temperate climates were much restricted in their migration across the Alaskan land bridge between Asia and North America.

[4] W. D. Matthew, "Climate and Evolution," *Annals New York Acad. Sci.*, Vol. XXIV., p. 212, 1915.

The Pliocene differs from the Miocene in the gradual advance of more temperate conditions in the middle temperate zone and of rigorous climates in the higher latitudes.

Let us turn to the history of primates in relation to this succession of Tertiary geographies and climates. We may use for this purpose the recent comprehensive phylogenetic studies of W. K. Gregory of the American Museum of Natural History.[5]

The anthropoid apes make their first appearance, so far as now known, in the lower Oligocene Fayûm deposits of Egypt. *Propliopithecus* occurs there, a very primitive but true anthropoid. This is a region where the Ethiopian and Eurasian faunas mingled and the apes clearly belong to the latter. During the course of the Oligocene the wide extent of tropical and subtropical forests throughout Eurasia must have given the primates opportunities for a wide expansion north and south, with a corresponding increase in numbers and diversity of species. Our knowledge of fossil remains is a blank, however, until the upper Miocene, at which horizon *Pliopithecus*, an ancestral gibbon, has been found in Europe. At about the same geologic level, in the Lower Siwaliks of northern India, have been recovered the fossil fragments of a number of genera. Of these, *Paleosimia* is an ancestral orang. *Sivapithecus,* according to Gregory, stands between the line of the orang and that of the *Hominidæ* but is not ancestral to either. *Dryopithecus,* which is represented by six species, three from the Siwaliks and three from Europe, stands close to the ancestral line of the gorilla and chimpanzee. After the lower or possibly upper Pliocene, no fossil remains of primates have been found until the Pleistocene. Here the human record begins and is more abundant than that of the apes. Most unexpectedly, however, a jaw of a chimpanzee has been unearthed from the Pleistocene of England in association with the Piltdown human cranium, *Homo dawsoni.* The occurrence in fact was so unexpected that the discoverers of the cranium regarded the jaw as belonging to the same individual. The careful anatomical study by Míller,[6] however, seems to show that the remains of a chimpanzee had accidentally become mixed in the same deposit with the remains of man. This evidence indicates that for a long period in the later Tertiary the anthropoid apes were capable of expansion under favorable conditions, and that on the contacts of the early human and the simian environments the two could be found in association. It emphasizes also the fact that active arboreal animals only by the merest chance give rise to fossils and may extend over a wider range of time and space than would be indicated by the recovery of their remains.

[5] "Studies on the Evolution of the Primates," *Bull. Amer. Museum of Nat. Hist.*, Vol. XXV., Art. XIX., pp. 239–355, 1916.

[6] Miller, G. S., "The Jaw of the Piltdown Man," Smithsonian Misc. Col., Vol. 65, No. 12, pp. 1–31, pls. 1–5.

In deposits of early to middle Pleistocene age the remains of man have been found in widely separated localities: *Pithecanthropus erectus* in Java, *Homo dawsoni* in England, *Homo Heidelbergensis* in Germany. By the time of the early Pleistocene the body of the *Hominidæ* was, however, about as well adapted to ground-dwelling as at present, as seen in the femur of *Pithecanthropus*. In the Neanderthal man of the Upper Pleistocene the form of the foot and the relative proportions of leg and arm show that man had already been a terrestrial animal for at least a geologic epoch. The jaw and teeth of the Heidelberg man show the possession of clearly human though very primitive characters, a complete change from the dental type of apes adapted to a frugivorous diet. As pointed out by W. K. Gregory, although the canines have diminished in size, the erect incisors, with an edge to edge bite, are well adapted for the biting and tearing off of flesh, and the powerful jaws were capable of crushing small bones. With the use of crude weapons for the killing of animals the modifications in teeth and jaws represent a carnivorous-omnivorous adaptation fully worked out in a terrestrial and predatory primate. Thus both in dispersal and terrestrial adaptation, as seen in the early Pleistocene, there is evidence that the origin of man goes back to a far more remote period of time. It appears probable, therefore, that this adaptation goes back to the Miocene. It is possible, so far as the fossil evidence is concerned, and leaving aside the problematic evidence of Pliocene eoliths, that the adaptation to the ground may have occurred in the early Pliocene, but the experience of paleontologic discovery indicates that the initiation of new adaptations usually goes back a considerable distance in time beyond their perfection and the resulting dominance of the possessors.

Assume, then, as probable, that by the early Miocene the differentiation of anthropoids had given rise to forms resembling somewhat the chimpanzee. This line of large-bodied, intelligent, and somewhat gregarious apes, though chiefly arboreal, would have possessed some agility on the ground. We may grant them also some degree of cooperation in hunting small animals, and in fighting they may have used sticks or stones as weapons. But such apes, even if thus progressive, would still have been at the mercy of the wolves and great cats unless they remained within reach of their refuge in the trees. The greater part of their diet must still have consisted of fruit, succulent vegetation, insects, young birds, and birds' eggs. Such a beginning was still far removed from independence from the trees, both for food and refuge. The limb structure must still at that time have been adapted for arboreal life with resulting inefficiency for a terrestrial habitat. The mentality must still have been far below that level of cunning, resourcefulness, cooperation, and courage necessary for the maintenance of apes of generalized form in competition with the powerful terrestrial fauna.

How was this step taken which transferred the habitat and transformed the quadrumanous arboreal man-ape into a bipedal terrestrial ape-man, standing nearly erect and facing the dangers of the ground? As noted previously, two answers may be made. The conventional one has been that organic advancement without calling upon any changes in geography or climate gradually adapted the ancestors of man to live more or less freely upon the ground and that then a racial ambition for conquest led him to press out from his original arboreal home as fast and as far as he was able. But the evolutionist is confronted here with several difficulties. The dangers of life were less in the trees. Why should a species of apes court voluntarily a more hazardous life? They could not be expected to have so solved its problems that they would be better off there than those allied apes which led a more conservative and arboreal existence. Without assuming an unproved inheritance of acquired characteristics, or more logically, a forced and strenuous natural selection with survival only of the fittest, how could those considerable modifications of limb and foot structure which so differentiate man from arboreal forms have been acquired? Furthermore, it has been found in other examples that the great impulse which leads in general to new and progressive faunas and especially to the transformation of habitats is change of environment from which the organisms can not escape.

Let us turn then to the second line of explanation. The change from warm temperate forests to the more bleak conditions of the steppes must have taken place in the Miocene most markedly on the northern and interior side of the newly raised Eurasian mountain ranges. But the forest animals of this region, when their former range became restricted, could no longer freely retreat, generation by generation, to the southward. They were isolated in archipelagoes of forest in the spreading grasslands as thoroughly as the orangs are now isolated within the sea upon the islands of Sumatra and Borneo. A park-like condition of scattered groups of trees as savannahs must for ages have contested supremacy here and there with the flora of the steppes. The usual consequence of such a repressive change upon an isolated fauna is its gradual impoverishment and extermination. That small part which survives must radically change in order to meet the new conditions. In this isolation under conditions adverse for the older mode of life is found a fitting cause for the origin of man; for the apes which were trapped in this way in central Asia were forced to win most of their living on the ground. There they must have faced greater dangers, to live or die as best they might. Such a precarious life must have exercised a stern elimination of the unfit, so that only the most agile, resourceful, and cooperative were able to survive.

Let us contrast these two hypotheses of the origin of the terrestrial

ape-man in some of their consequences. It is a general law, the law of parsimony, that a species does not expend energies unnecessary in its mode of life: domesticated animals tend to lose resourcefulness and hardihood; birds isolated upon oceanic islands and becoming terrestrial lose the power of flight. In contrast to this it is seen that coordinated change in several parts of an organism with resulting greater efficiency in some new and more strenuous mode of life must be forced upon organisms, and the efficient combinations of organs sifted out of chance variations by a process of natural selection. The law of probabilities declares that such a new and efficient combination of organs could not arise merely by spontaneous and orthogenetic variations in each unrelated part.

A life in tropical forests does not tend to lead moderate-sized arboreal creatures toward a terrestrial existence. On the borders of such forests or in open places a generalized form might make excursions upon the ground, but it would remain essentially arboreal and in the face especially of the powerful Tertiary fauna would have to keep the trees always in sight as a refuge, or adopt some mode of life such as seen in the ground squirrels which would protect them from their foes.

A tendency to increase in size resulting in giantism in certain species is manifested in most families of animals. A sufficient increase in size would force an arboreal animal to live partly upon the ground, since it could not leap freely through the trees. Its accompanying strength and ferocity might at last give it protection in a partly terrestrial environment, as seen in the gorilla; but this is the choosing of a retrogressive line of evolution and does not tend to rise to the intellectual level of the human plane. Rather it is a line developing away from man and toward a creature bear-like in form and habits. It does not appear then to be parallel with the course of the human ascent to a higher plane of life.

This ascent from ape to man involved a physical transformation shown in a changed foot structure, changed ratios of the limb-lengths, a changed profile of the backbone, a shortening of the jaw and a changed dentition. It involved an even greater mental transformation through which man has become set apart from all other mammals. Early man found his line of greatest efficiency in his superior mentality and through this superiority he could face his formidable adversaries. These transformations with efficiency in new modes of life could be effected most readily and perhaps only by a strenuous natural selection. The death rate must have risen and sought out unsparingly all those least able for any reason to meet the new conditions. In places the rising death rate would have led to extinction, elsewhere it spared a limited number, but these by the elimination of their non-progressive fellows had become a new kind of creature. Furthermore, separated

now by geographic barriers from their nearest relatives of the trees, their hereditary strain did not tend to become submerged. Winning life by warfare waged first against them; at last successful, they carried that warfare as an offensive campaign against their terrestrial foes. From the interior Eurasian center of dispersal, man, having won efficiency upon the ground, would press out in a series of waves. *Pithecanthropus,* found in the early Pleistocene of Java, was, as shown by his femur, already far from the arboreal transformation and his location in Java has no necessary relation to the original home of man. Indeed, as Matthew has argued, the lowest forms represent the earliest migrations and are apt to be found far from the original home. In tropical forested regions and on such remote islands as he could reach, the earliest and lowest types of man have found the conditions for longest survival.

On the southern side of the Himalayas the Miocene and Pliocene faunas of the Siwaliks were forest faunas. Although the remains of a number of species and genera of primates have been found, no trace has been recovered as yet of a semi-erect, bipedal, carnivorous ape, although such, if present, would presumably have been better adapted for fossilization. If, as seems probable on other grounds, the transitional forms from ape to man were in existence at that time, they had not pressed out of their original climatic environment. As soon as they did so, on account of their dominance in numbers with increasing dominance over nature, and because of their terrestrial habitat, the chances of their leaving fossils were better than for other primates, as illustrated by the record of the Pleistocene. The Miocene ape-man may therefore be more hopefully sought in deposits of the open and temperate regions of central Asia rather than in the alluvial deposits of the more southern tropical forests.

Finally, if there be probability to this view, it contributes its weight as one of the elements of theory toward a truer philosophy of evolution. Man is seen to be not a mere product of time and life—the expression of a fancied innate tendency toward the human state—but is peculiarly a child of the earth and is born of her vicissitudes. So far as evolutionary history has been interpreted, there is found no indication that low and isolated lands with monotonous history, such as illustrated best by Australia in later geologic times, would ever have carried evolution forward to its fruition in intellectual life. Yet in the earlier Paleozoic ages the northern lands, flooded by shallow seas, were often of this character. Contrast with this geological monotony which once seemed likely to endure without end, the expansion and diversification of the land-surfaces through later geologic times, accompanied recurrently by sweeping climatic changes; that oscillation of topographic and climatic conditions which is seen to have stimulated progress.

Or again, one vast and monotonous land surface, such as is seen on the planet Mars, is not regarded as an environment well adapted to stimulate marked advances in evolution. The waves of progress have required first restriction and isolation with wide variations of conditions, so that unlike faunas could be produced and the better types acquire dominance within a limited habitat. Second, is required the migration, mingling, and competition of faunas. Judged by these principles, the post-Silurian history of the northern hemisphere is seen to have been increasingly favorable for the evolution of the higher types of land life. But that this should have been the sequence of the physical events of earth history has depended upon obscure conditions in the earth's interior which appear to have no close correspondence in the two celestial bodies whose surfaces we are able to study—the moon and Mars. The progress of life on the earth has been highly favored, consequently, by the rhythmic pulses of diastrophic and climatic changes which have remorselessly urged forward the troop of living creatures. The progress of organic evolution has depended upon a series of fortunate physical events, conditioned in the internal nature of sun and earth, rather than the byproduct of mere life activities as expressed in orthogenesis through long periods of time. Evolution is in no sense an inevitable consequence of life, and the compulsion of climatic change has been more than once a fundamental factor in the age-long ascent from protozoan to man.

THE WAYS OF PANGERMANY

By DAVID STARR JORDAN

STANFORD UNIVERSITY

IT is a common remark both in America and in Europe that "there are two Germanys," the one warm-hearted, easily led, minutely efficient; the other ambitious, ruthless, scornful of public opinion because obstinately blind to its existence, and so confident in the perfection of its adjustments that it seeks to impose them on the whole happy-go-lucky world.

The one of these groups, though split up into more than a dozen factions, possesses most of those qualities a tolerant world was wont to admire as German scholarship, German friendliness, and German efficiency.

The other group, uncompromising, vindictive and determined, is represented and controlled by the "Alldeutschtum Verband" or "Pangerman Union." The word "Pangermanism" designates the tenets and acts of this society. It is in no proper sense to be compared with the similar terms, Panslavism and Panamericanism. The first of these represents an uncrystallized political sentiment reactionary in most regards, but incoherent in action. The second is, at the most, an expression of geographical good will.

Pangermanism is a call to action, and action of a very definite kind, the substitution, in a world carelessly dominated by the English-speaking races, of a well-knit and coherent system of Germanic discipline. Behind this it is an organized league of exploiters, aristocrats, militarists and visionaries willing to go to any lengths in or out of Germany to advance their own purpose. Closely associated with these is a General Staff, "persistently disloyal to the German government."[1]

One of the most characteristic statements of the ultimate purpose of Pangermanism is that attributed to Professor von Stengel. He is cited as opposed to the Hague Conferences and similar attempts at International agreement because no such conferences would be necessary under a "German Peace" or the "superstate in which Germany would enforce order on the world."

He is quoted as saying:[2]

[1] "The Defeat of the German General Staff," Herbert Sidebotham, *Atlantic Monthly,* November, 1916.

[2] Herbert Bayard Swope, "Germany for a World State Born of War," *New York World,* November, 1916.

The one condition of prosperous existence, especially for the neutrals, is submission in our supreme direction. Under our overlordship all International Law would become superfluous for we of ourselves and instinctively give to each one his rights.[3]

That the activity of Pangermanists gave the direct impulse to the present war as well as to the insane military rivalry which came so near making the war inevitable is a matter of history. It is also clear that the future development of Europe hinges on the ability of the German people to control these elements, as after the Boer war the British people were able to hold in check the like elements among themselves. In all nations the struggle for freedom appears to the privileged classes as disunion and an abatement of the "patriotism" of international hate. Such conflicts exist in every country, but nowhere else have the elements of reaction been so thoroughly integrated as in Prussia.

The *Alldeutschtum Verband* for the promotion of German world-control was organized in Berlin on the ninth day of April, 1891. Just before this, in November, 1890, the German government had ceded to Great Britain the island of Zanzibar in Africa, receiving in return the island of Heligoland in the North Sea, not far from the German coast. Zanzibar was the key to vast colonial possessions rich in the "Mirage of the Map," to borrow a phrase from Norman Angell. This fitted into the scheme of the "Cape-to-Cairo Railway" and with other plans of British Imperialism.

Heligoland was a small island, apparently destined at last to be washed away by the waves, then known mainly as a summer resort. But it had potential value as a guard to the German coast, and, with the Kiel Canal, as a shelter to the German navy. This exchange was mainly the work of the young Kaiser, and at the time it aroused considerable criticism, for it seemed to sacrifice Germany's colonial interests to a secondary matter of local defense.

The *Alldeutschtum Verband* stood against policies of conciliation of whatever kind. It was therefore, from the first, in opposition to the acts of the ministry in power, for no government on earth can subsist without a certain degree of conciliation and compromise. Its center was among the agrarian nobility. With these men were associated imperialists, expansionists, militarists, advocates of a "vigorous foreign policy," and among them were naturally army officers and dignitaries of the church. For, as John A. Hobson has shown, the army is always the "right arm of privilege" and "its left arm is the state church." We are told:[4]

[3] This attitude stands in direct opposition to the blunt dictum attributed to Bismarck, "None of this cock-o'-the-walk business for Germany; Europe won't stand it."

[4] Ernest Denis, "Le Mouvement Pacifiste," Berne, 1916.

In the beginning the League counted among its directors personages of the highest rank, such as Cardinal Bopp, bishop-prince of Breslau, and the Count von Stolberg-Wernigerode, former governor of East Prussia.

Professor Hermann Fernau observes:

In Germany the chauvinist pro-war agitation has been promoted and encouraged among the most influential circles by the Junkers, militarists and Pangermanists. In the Pangerman Union (*Alldeutscher Verband*), in the Navy League (*Flottenverein*), the Defense League (*Wehrverein*), and similar associations, Germany already possessed gigantic organizations, extending over the whole empire, which were preparing her in accordance with a definite program for the "inevitable" war for world supremacy.[5]

The actual leadership of the League has never been made conspicuous. It would appear that its executive heads have mainly been retired generals and admirals. Occasionally professors, as Carl Hasse of Leipzig, have served this purpose. In general, however, some "respectable person of bourgeois origin" is made president, such choice serving to obscure the aristocratic-plutocratic-militaristic nature of the organization. Its present executive, Herr Class, chauvinistic but undistinguished, seems to bear out this statement. Under its auspices, "Capitalistic ventures" such as the "Land Owner's League," have promoted war-preparation and war-making in the interest of financial and territorial gain, and also as a backfire against socialism and democracy.

The society numbered in 1897 about 12,000 persons, in 1902, 22,000. In 1914 the number was estimated about 30,000. It was reported some twelve years ago that 2,300 members were resident in foreign countries, part of them naturalized, part remaining alien. Twenty-three of the two hundred and seventeen chapters forming the union had then been established in foreign countries, largely to bring expatriates, wherever placed, into the direct service of the League.

The avowed purpose of the union was to deepen national feeling and to force the German people to recognize their responsibilities as a "world power" to nations overseas. It has strenuously upheld the doctrine that for the state there can be no question of morals, for above the state there exists no power to compel obedience; hence the need for one supreme world state, powerful enough to ignore balances of power, and wise enough to form a complete overlord.

The immediate aims sought were these:[6]

1. A strong colonial and emigration policy for Germany.
2. The promotion of German schools in foreign countries.
3. The furtherance of patriotic feeling and the suppression of all tendencies opposed to nationalism.
4. The control of all education in the interest of national policy.

[5] "Weil Ich ein Deutscher bin," English edition.

[6] These statements and some other quotations are taken from private letters from German colleagues.

5. The cultivation and support of all nationalistic movements among Germans at home or abroad.
6. The furtherance of an energetic political movement in behalf of German financial interests (*Interessenpolitik*) both in and out of Europe, always determining the trend of foreign policy towards "practical results."

By "practical results" we must understand not national glory, but the purpose for which national glory is mainly evoked—financial gain.

The early work of the League was carried on chiefly in three directions:

1. Propaganda for naval expansion resulting in the formation of the Navy League (*Flottenverein*) and Army League (*Wehrverein*).
2. Propaganda in favor of the Boers, during the war in South Africa. ("500,000 marks were collected for this purpose during the Boer war.")
3. Attacks on the administration of the chancellor, Count von Caprivi, because of his conciliatory attitude towards the Poles.

To these may be added:

4. The Emperor's appeal for "the union and conservation of all the German tribes."
5. The necessity urged by von Moltke of "freeing the mouths of Germany's great rivers."

At home the efforts of the League served to promote the projects of expansion, exploitation and military expenditure. Abroad, the purpose was to lay especial stress on Foreign Germanism (*Das Deutschtum im Auslande*), and in this interest to foment international discord. At all times it has stood for war-at-any-price as the basis of national virility, and for those uncompromising policies which have made Germany feared or hated by other nations.

Among the notable catchwords or slogans of the Pangerman propaganda are these: "World Concerns" ("Welt-Politik"), "Big Business" ("Real-Politik"), "World War," "Slavic Peril," "Anglo-Saxon Menace," "British World-Monopoly," "French Revanche." Geographical aims are summed up in these expressions: "Berlin-Calais," "Berlin-Riga," "Hamburg-Salonica," "Hamburg-Bagdad-Persian Gulf."

Retired officers of the army and navy have been conspicuous among the spokesmen of the League. Their discussions have followed this "well-worn pattern, the splendors of war and the immorality of peace," leading up to "the absolute necessity of war for the realization of Germany's world ambitions."

The best-known and perhaps the ablest of these propagandists was General Friedrich von Bernhardi, ex-member of the General Staff, whose writings and speeches, lucid, logical and inhuman, need no

further notice here. Their keynote is found in these words, which the present writer heard Bernhardi utter:

> Law is only a makeshift, the reality is force. Law is for the weak; power for the strong.[7]

More fiery and effusive than Bernhardi, but far less coherent and self-contained, is General von Keim, likewise a former member of the General Staff. Previous to 1914 he had traversed all Germany prophesying and urging war with England as well as with Russia. The following utterances are typical:

> The way to German union and power is not paved with ink bottles, black type or parliamentary resolutions. It is marked by blood, wounds and deeds of arms. States are maintained by the means used in creating them. Hence the need of a strong army and a mighty fleet. . . . A secure place in the world is alone for that people which is filled with the spirit of war. . . . To the German youth it must be made clear, and to the German maiden as well, that it is your right to hate the enemies of your Fatherland. War, war on both frontiers! We must learn to hate, and to hate with method. A man counts little who can not hate to a purpose. Bismarck is but another name for hate.[8]

The late Admiral Breusing, ex-member of the Naval Staff, in an address in Basel, Switzerland, in 1913, fixed the date in which Germany would declare war, as the summer of 1914, a period also indicated by Bernhardi. Breusing described in detail the proposed policy of the German navy. This was to wear out the British fleet by minor attacks until, in a final conflict, the superiority of German guns and German seamanship should bring a culminating victory.

The German people have never governed themselves. And we may note that whenever, in any nation, the people neglect or fail to assume control of their own affairs, others will seize the lapsed sovereignty and use it in their own interest. Here was Pangermanism's opportunity. Brailsford asserts that "the function of the Prime Minister is to have his hands forced." Almost every German chancellor, from Caprivi to Bethmann-Hollweg, has had this experience, and at the hands of the Pangermanists.

The "stronger" the government of a nation, in the usual or military sense of the word, the more vulnerable, in a crisis. A "strong government," unhampered by parliamentary vote or by constitutional checks and balances, is at the mercy of intrigues from within. The first duty of a strong government, it is claimed, is to take care of the "interests," hereditary, military and financial, and its underpinning becomes honeycombed by their ramifying invasions. No government desires or expects that such elements should dictate its policy, but the farther removed from the people the feebler its power of resistance.

[7] "Das Gesetz is nur ein Versuch; die Wirklichkeit ist Gewalt: Gesetz ist für die Schwachen; Gewalt für die Starken."

[8] "Das deutsche Chauvinismus," Ottfried Nippold, Frankfurt, 1913.

The policy of Prussia, and therefore of Germany, has been increasingly determined by the Pangermanist group. With a large use of sentiment, and especially of the swelling idea of German superiority, it has steadily advanced towards the exploitation of backward countries, the permeation of all regions by German agents, and the advancement of the German nobility. War-scares at home and abroad have furnished effective weapons. Its unyielding and contemptuous attitude in exaltation of military and naval efficiency has impelled other nations to lay aside their differences, internal and external, and to stand together in self-defense.

The movement of Pangermanism may be narrowly defined as an effort towards extended domination over the continent of Europe and towards control of colonial areas and protectorates in Asia and Africa. By various devices it has secured a strong hold on the court, in military circles and among the "intellectuals" of the schools and universities. It has largely directed the "*marcheroute*" of the press, and through the all-potent Ministry of Public Instruction, it has debarred scholars of democratic tendencies from appointment to professorships, on the other hand insuring in almost every university the presence of professors of history and politics in line with its assumptions. It is the social, political and military agent of reaction in Germany, and it has fortified itself as the visible stronghold of German patriotism. It has been a large factor in turning the government itself into a huge business combination run for the advantage of wealthy corporations, which receive rebates and subsidies of various kinds, and who, in turn, care for their employees assiduously, but with a sole idea to getting from them the highest possible service for the least possible expenditure. Pangermanism has furnished the German people a "*Kultur*" or discipline of which the leading feature is not personal initiative, the discipline of the individual, but obedience and uniformity, the discipline of the caste. It has apparently disclosed the spectacle of a gigantic, peaceful, unified empire which, "in shining armor," would hold its neighbors as well as its "vassal states" in peace. This it would accomplish through its own industrial and military supremacy, and through the unity and continuity of purpose which comes from autocratic as distinguished from parliamentary government. The great advantage German discipline would confer on the rest of the world would, it was held, outweigh and justify the sorrow and desolation which might be incidentally caused in the process of extension of these salutary and profitable methods. The assumed superiority of the Germans gives them unquestioned might. "Might creates need and need makes right."

The aggregate efforts of the Pangerman Union pointed towards the condition in which Germany found herself at the outset of the war. In brief, the nation had become a gigantic business corporation in which

every force, internal and external, was devoted towards the advancement of certain favored groups, agrarian, industrial, commercial, financial. To this end were directed all available resources, rebates, subsidies, interlocking directorates, tariffs, underselling in foreign markets at rates less than the cost of production at home, crushing of rivals, native or foreign, the paternal care of workmen with corresponding repression of unrest and of ambition. This system rested largely on borrowed capital. Its methods necessitated constant and rapid expansion, and in the end it must defeat itself. The form chosen for the final crash was international war.

This "frenzied finance" of Germany had its parallel in other nations, but rival combinations were less efficient, less bold, less successful in their hold on governments or people. Yet for years it has been true that the chancelleries of Europe in general have been only the firm names under which exploiters of Asia and Africa have carried on their enterprises.

Before the war, to the German people at large, the efforts of the Pangermanists seemed of little importance. While I was in Bavaria, in 1913, Bernhardi was described to me as a "disgruntled cavalry officer who had failed of promotion." Not much stress was laid on his utterances, and even his startling book on "Germany and the Next War" was scarcely noticed by the intellectual classes. The land was prosperous and peaceful, endangered only remotely by the alleged jealousy of "commercial rivals" in England, and by the menace of "natural enemies" in France and Russia. The Emperor, himself, however, devoted to war-display and to the heroics and romanticism of force, apparently had no desire to waste substance in actual warfare. The chancellor and the foreign minister were distinctly men of peace. It was generally agreed that the Pangermanists were "a mere handful of theorists," "extremist dreamers of world power, hardly to be taken seriously." Their efforts seemed to fall into the "stream of events," and few saw clearly that this very stream of events was largely of Pangermanist creating. After each crisis arose the question: "What else can we do?" And this furnishes the final argument for the plunge into war.

In every aggressive movement the Pangermanists have forced the pace and furnished the driving power. Says Kurt Eisner in the paper already quoted:

> They have acquired a greater influence on the shaping of national policy than even the mightiest combination of interests among the great landholders and capitalists. . . . Although the government has always been arrayed against the unbridled policy of the Pangermans, nevertheless the conduct of its head has become more and more Pangermanist. This is because the government has always submitted eventually to what it first opposed, acting in agreement with the entire mass of public opinion played upon from Berlin by Centristic (reac-

tionary) influences. . . . From the first projected naval program to the most recent law for defense, every single plan for preparedness has originated in Pangermanist circles. They were the advance guards. . . .

The program of the Pangermanist Society is simple and clear. The "nationalistic" illusions are merely an idealistic by-product for the delectation of affiliated teachers and professors. The real goal is the acquisition of colonies where Germans may settle, where German peasants may cultivate the soil that may supply us with raw materials for our manufactures and use our products in exchange. That is the "sure market," the dream of the German export trade. . . .

This colonial empire can be obtained, according to the view of the Pangermanists, only by strengthening Germany's position as a power in Europe. For this universal military service must be pushed to the utmost limit, and there must be unhindered building of war-ships for whose efficiency the acquisition of coaling stations and naval bases is indispensable. . . .

Besides this the society has the cooperation of a staff of "intellectuals" whose activities extend everywhere. The latter, having acquired, mostly by foreign travel, certain kinds of knowledge and experience, are welcome to the press as experts whenever there is a controversy on world-politics. On such occasions these propagandists bob up as collaborators and information suppliers for the press, like snails after a rainstorm, and public opinion is delivered over almost defenseless to them. The secret and the danger of their influence lie in the fact that public opinion is invariably swept forward by the irresistible rush of events, while the Pangermanists by unflagging energy have for years been preparing these very events.

Only autocratic governments can pursue "a vigorous foreign policy," such policy admitting of no divided councils. Division of council constitutes the safeguard of democracy. Hence democracy fails relatively under the abnormal stress of war, while the weakness of autocracy appears in the ease by which war may be thrust upon it. War-making is incompatible with the methods and spirit of democracy. This fact, brilliantly set forth by Marcel Sembat ("*Faites un Roi sinon Faites la Paix*"), justifies the belief that a democratic Europe would be a conciliated Europe. As Jules Frœlich pointed out some years ago, "the Pangermanist movement is the sole obstacle to the formation of the United States of Europe."[9] The continent for the most part was ready for the essential realities of such a movement, though doubtless not for its administrative forms. The governments generally were not averse to mutually helpful international agreements. The Pangermanists, however, with the reactionaries everywhere, saw neither glory nor profit in international equality of rights. The idea of unlimited sovereignty rose above all rival conceptions. To them a sovereign state stands superior to all individuals, all treaties, all agreements, all morals, and is responsible to no authority. As Treitschke put it, a nation can be guilty of no sin save the unpardonable one, "the sin against the Holy Ghost" of being small or backward, and thus at the mercy of other states. In this view, war has no moral quality, good or bad. It is

[9] "Le Pangermaniste en Alsace."

merely a process, a way to an end which, if attained, justifies the means. Thus exploitation, if successful, becomes a right, and small states exist only in the temporary convenience of great ones whose ultimate duty is to absorb them.

And as autocracy must maintain itself against the "noxious weeds" of the time—democracy, socialism, pacifism, and internationalism"—it must finally rely for its permanence on foreign war, "the swift remedy," as Treitschke avers, "for internal disunion and waning patriotism."

The movement of Pangermanists may be looked upon as at once a conspiracy, a romance and a religion, romance and religion being primarily devices to conceal from a romantic and idealistic race the sordid materialism of its real aims. In practise it is a conspiracy against the freedom of the German people, on whom it would tighten the chains of military and industrial despotism. In exchange for liberty it would offer security, a tolerable present condition as a substitute for hope of future advancement. It is also a conspiracy against the freedom of surrounding nations, part of its purpose being to extend the Prussian system over all districts inhabited by people of Germanic origin, as well as over those which intercept Germany's road to the open sea, and those which lie in the way of her "*Drang nach Osten.*"

The Pangermanist cult may be conceived as a romance in its reliance on medievalism and tradition. By devious arguments from history Pangermanists justify German claims on neighboring regions inhabited by races alleged to be of Teutonic origin, or which once yielded allegiance to the "Holy Roman Empire." Again romance appears in the pursuit of the "Mirage of the Map," in the ambition for overseas possession in "a vast continuous area which shall be purely German." In Africa the holdings, it was planned, should stretch from the Atlantic to the Indian Ocean, bound together by an interoceanic railway system, the whole to be ruled, according to Professor Hans Delbrück, "by an aristocracy of German planters who shall evolve a German-African national pride." Delbrück admits that there could be no economic gain to Germany in the ownership of such a black empire. It therefore would rest on no sordid expectation of profit. It is purely and solely a castle in the air, built up of "sheer sentimentality," a leading factor in all German affairs. This pursuit of romantic ideals by means of intimidation and force has had its effect on the Germans' estimate of themselves. Admitting all that we may of the profundity of German science, of German skill in the application of knowledge toward human betterment, of the nobility of the best art and the best literature of Germany, there remains, in these days, a great disparity between German greatness as the world sees it and as the Germans see it themselves. This chasm is indicated in part by the Pangermanist

contempt for other peoples, the "degenerate" French, the "worn-out" Italians (except when allies), the "barbarous" Russians, the "hypocritical" British, and the "dollar-chasing" Americans. The unflinching lucidity of the French, the artistic sensitiveness of the Italians, the idealism of the Russians, the sanity of the British, the personal vigor of the Americans are unrecognized in the mystic wilds of Pangermany. This throws light on the marvelous failure to understand other peoples which has been the bane of Germany's diplomacy, even staying the march of her militarism. For the judgment of the world is a solid fortress against which armies break themselves in vain.

The philosophy of Pangermanism implies prismatic perversions of morals and of fact. Thus Dr. Hugo Münsterberg, professor in but not of Harvard University, in his recent book "Tomorrow," illustrates this:

> Colonies will be grasped, seaports will be sought, and areas with untapped mines will be coveted, and yet it would be historically untrue to stamp even such aspirations as selfish aggression and as immoral lust of the conqueror . . . nationalistic ambition serving an idea is loyalty and faithfulness in the fulfillment of a mission which is received from history.

Thus the seizure of Kiau-Chau was an act of "idealistic devotion to the demands of the national soul." As for "German truth," the author continues:

> I think it is a low view of scholarly truth and a lower view of patriotism that misleads the many to such criticisms [as to veracity]. They fancy that truth is only a kind of photographic copy of an outer reality. They are not aware that every so-called truth is a remolding of life-impressions, a reconstruction of experience, a free creation of the intellect which can never be severed from the purposes of the free creating mind.

Through romance, Pangermanism rises to be in a degree a sort of religion, a primitive religion of hate. It has, it is said, the approval of "our good old German God." Its ritual is thus indicated by Otto von Gottberg:

> Love for one's brothers, for the Fatherland, the Emperor, and the Empire, for victory which will give peace to the living and rest to the dead, these are the teachings not alone of heathen, but of Christian belief. Therefore war is the highest, holiest exhibition of human action. . . . This is the Kingdom of Heaven for young Germany. It is, as it were, to knock at the door of our Lord God! (*"an unseres Herrgotts Tür zu klopfen"*).[10]

A marked feature of the Pangermanist movement was the effort for the "recovery of lost Germans" ascribed to von Buelow in 1902. This plan is thus described by Bernhardii:[11]

> It should provide that the German element is not split up in the world, but remains in compact blocks, thus forming, even in foreign countries, political centers of gravity in our favor, markets for our exports, and centers for the diffusion of German culture.

10 Nippold, "Das deutsche Chauvinismus."

11 "Deutschland und der Nächste Krieg," 1913.

The number of "lost Germans" who could be thus "recovered" and used in Pangermanist operations was reckoned in millions. It was claimed that the German element in the United States amounted to ten millions, with another ten millions in the rest of the outside world. This estimate, greatly exaggerated in the first place, proved very disappointing. The number of Germans who became political agents paid or unpaid was relatively small, not many thousands at the most, and their ill-timed services have been costly in other nations as well as in the United States. But it is a fact beyond question that men under control of the Pangerman Union have permeated every part of the world, and that they have been a large factor in bringing the name of Germany into disrepute even before they were called into special activity by the demands of war. According to John Hay, their operations "left Germany without a friend in the world except dependent Austria and subsidized Turkey."[12]

A concurrent purpose of *Alldeutschtum* has been to compel the use of the German language wherever German control extends. It demands the complete extirpation of foreign words in Germany, as well as the suppression of all other tongues, French, Polish, Danish or Flemish among those alien peoples whose territories are included in German conquests. This process of "*Entwelschung*" (deforeignization), so irritating to the natives of Alsace-Lorraine, and to those of German origin even more than to those of French, has been pushed as a salutary necessity.

The influence of Pangermanism was dominant in the onset of the present war. Although the conflict was initiated and precipitated in Germany, the German people as such had no conscious part in the affair. To this day most of them believe that their nation was the innocent victim of an iron ring of eager enemies. It was relatively easy for the Pangermanists to persuade the populace that they had been encircled ("*eingekreist*"), and that war had been forced on them by Russia, by France, or by Great Britain, according to the demands of the occasion. For violent utterances could be culled in abundance from the foreign press, of exactly the same tenor as those of Keim, of Bernhardi, or of Count Reventlow, editor of the chief Pangermanist organ, *Die deutsche Tageszeitung* of Berlin. Unhappily every country, even our own, has its group of chauvinists and mischief-makers. It is significant that in early July, 1914, a group of international statesmen met in Paris to discuss, among other things, measures to save Europe from its "patriotic press."

An organization bent on violence is a special menace to an autocracy because autocracy possesses no safeguard against military pressure. In the democracies of Europe the military groups have been under a cloud.

[12] "Life and Letters of John Hay."

In France the party of "*revanche*" has been discredited and humiliated by the Dreyfus case and by the collapse of the futile heroics of Boulangerism. The calamitous Boer war unhorsed the British Tories. German reactionaries had met with no such check, having had largely their own way since the downfall of Napoleon. The revolution of 1848, directed against their methods, ended in the expatriation of the revolutionary leaders.

In the devious and halting diplomacy which followed the first Balkan war it is not difficult to trace the withering influence of Pangermanism. The futile establishment of the Kingdom of Albania which forced the second Balkan war, the unwillingness either to do justice to the Balkan peoples or to let them alone, the paralysis at critical moments of the honest efforts of the German government to work for peace—all these find explanation in the maneuvers of Pangermanism. To such intrigues we may ascribe Germany's contemptuous refusal to restrain Austria's menace to Serbia, her haughty declination to take part in a European conference, and the compulsory insistence of the General Staff that the Kaiser should declare war on France on pretexts or causes never verified and now known to have been trumped up. When previously the Kaiser and his prime minister had ventured to exert pressure on Austria to keep the peace, the effect was neutralized or perhaps suppressed by the Pangermanist, von Tschirsky, ambassador to Vienna. Take Jonescu, late prime minister of Roumania, has charged the responsibility for the attack on Serbia to the Pangermanist trio, Count Tisza, premier of Hungary, von Tschirsky, and their active agent in Austria, Forgach. Again, after Russia and Austria had reached some sort of peaceful understanding, the Pangermanists forestalled the Kaiser's acquiescence by organizing a monstrous popular uproar, the excuse being that Russia had begun to mobilize. In this demonstration the militaristic and clerical journals took an active part after the fashion of their kind.

Thus, on a basis of lies, emotion and patriotism, the Pangermanists arranged a crisis by which they swept Germany from her feet, and with it all Europe into the abyss. The Emperor and his government were forced to declare a war which they did not welcome, but for which Pangermanist pressure had made such thorough preparation that the nation apparently could not escape. The fateful word "mobilization" which brushes aside all civil authority, became the lever for Pangermanism's operations.

On July 30, three or four days before Germany's actual declarations of war, the semi-official organ, the *Lokal Anzeiger* of Berlin, under control of the Crown Prince and in full sympathy with the Pangermanists and without authority from the government, placarded the German cities with the premature statement that national mobilization

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was ordered. This unwarranted act carried everywhere the certainty of war and "forced the hand" of the chancellor. It has long been known in Berlin that while the false statement was promptly telegraphed to St. Petersburg, where it produced great consternation and rushed the nation towards war, the telegrams in contradiction were suppressed in the Berlin office and not sent out until too late for them to have an effect.

By lies concerning France and by suppressed telegrams to Russia the war was brought on. "What else can we do?" was then the problem of Germany as well as of Russia and France. With nations armed to the teeth, the line of least resistance is the one which leads to war.

This "patriotic" trick invites comparison, as Mr. E. J. Dillon has shown, with Bismarck's mangled telegram at Ems which furnished the incident on which hinged the Franco-Prussian war.[13]

An anonymous Pangermanist using the pen-name of "Julius Alter,"[14] able, ruthless and shameless, in a violent attack on von Bethmann-Hollweg, asserts that this act of the *Lokal Anzeiger* justified itself in the absolute necessity of war:

> All Germany felt and knew that the fatal hour had struck. Only Bethmann-Hollweg clung to the hope that a peaceful solution of the "incident" could be found or at least that hostilities could be confined to Austria and Serbia. . . . It is plain that his untiring efforts to the very last hour, regardless of military happenings, were directed to prevent at any price the long, unavoidable war. In vain were the warnings of the General Staff. The Minister of War and men in authority in the naval department pointed in vain to the need of mobilization. They succeeded in half-convincing the Emperor of its absolute necessity. On Thursday, July 30, the afternoon police papers and the Berlin *Lokal Anzeiger* published the fact of the mobilization, but the interference of Bethmann-Hollweg served to nullify this decisive action.

In the matter of Belgium the military authorities similarly defined civil authority. "Junius Alter" goes on to say that

> during the war the idea of the annexation of Belgium was to the chancellor like a red rag to a bull. He felt morally bound by this question, especially as on August 4, 1914, he invented a "breach of neutrality" for Germany and promised to make restitution. How, indeed, could the honorable Bethmann-Hollweg dream of holding Belgium after he had given his word?
>
> That special interests play a rôle in the Belgian question, for which the word Antwerp is significant, need not be emphasized. . . . Not less gently did the Chancellor propose to deal with France. . . . That the sacrifices we were forced to make in the Vosges and on the Meuse line must be avoided in any future war, and that part of the Franco-Belgian coast would serve as a useful

[13] For a full account of this affair see Dillon's "Ourselves and Germany," the account in question being quoted in the World's Work for November, 1916, page 10, under the title of "Another Ems Message."

[14] "The German Empire on its Way to a Historical Episode," privately printed as confidential and anonymous; a translation given in the *Chicago Daily News*, July 15, 1916.

flank position against England—all this seems never to have occurred to Bethmann-Hollweg.

These and similar projects, the conquest of Belgium (and of Holland as well), the seizure of the two northern departments of France (Nord and Pas de Calais), the creation at Boulogne of the greatest seaport in Europe, the exaction of a huge indemnity from Paris, all were commonly discussed in Pangermanist circles when the writer was in Germany in 1913.

The man on the street refused to take them seriously. The German ministry, the two war portfolios certainly excepted, were opposed to the methods and plans of the Pangermanists. Their success in forcing war, and especially in the insistence on submarine operations, resulted in a bitter feud between the chancellor and the minister of marine, von Tirpitz. The Kaiser has apparently sided with the more moderate group, the retirement of von Moltke, von Tirpitz, and finally of von Falkenhayn, giving certainty to this view. However, for a considerable time the partisans of "frightfulness" prevailed, their specialties for terrorization, the submarine and the Zeppelin, being freely employed against life and property of non-combatants in the enemy countries, to the great loss of moral prestige on the part of Germany without compensating military advantages.

The real problem of the present is not how to "crush Germany," but how to redeem her from her Pangermanist betrayers. This only the Germans themselves can achieve, and this they seem likely to accomplish. The influence of Count Reventlow and his type is distinctly waning and the long-suppressed voices urging democratic control are more and more audible. If they can rise above the sordid and medieval ideals of Pangermanism, taking the future of their nation sanely into their own hands, and if their present rivals meet them with a like sanity, the greatest problem of civilization will be well on its way to solution. And permanent sanity for the world can be secured only by the complete separation of military force from financial adventure.

THE PRESENT CHINA

BY DR. ALFRED C. REED
SAN FRANCISCO

THE subject of the present China needs no apologist for its timeliness. While the European war has forcibly usurped popular attention, there are movements on foot in China, some antedating the war and some growing out of it, which are significant and prognostic. It is not for any one person to give a valid final judgment on the China of to-day, much less a rational prophecy of the near future. In this paper, therefore, it is not designed to make a complete study, but only more practically to discuss certain aspects of the present situation in China as viewed at first hand.

There are several cogent reasons why China to-day is vastly important to America. In the first place, America stands in a peculiar relation of guardianship. Not exercising any protectorate, the only great power not to force land concessions from China, America has at the same time brought moral pressure to bear which has created and so far guaranteed the open-door policy, and has saved China from partition or from an equally suicidal grant of special privileges to any one nation. The restoration of the Boxer indemnity by America, and its application to scholarships for Chinese students in America has furthered the influence of America's voice in Chinese affairs.

Again America stands in the relation of example. Since her own system is no longer efficient and since its inefficiency is becoming recognized even by herself, China has been turning, one might say, almost naturally to America as to the one great power which, being disinterested and having the excellence of western civilization, might therefore be taken as an example in her own reconstruction. But a pattern inherently connotes obligation. A collective or national obligation is with difficulty recognized individually. And America individually is lamentably far from recognizing her obligation as an example to China.

China is vastly important to America because of commercial opportunities. This too America realizes only in part. Here, as in other relations, the war has given America a rare opening which needs immediate improvement to be successful. Heretofore, for example, American cotton has been exported to England and the finished fabrics in English hands have found a ready market in China. There is no reason why America should not supply the finished product direct. The Standard Oil Company and the Singer Sewing Machine Company are conspicuous among the very few American business concerns which have a strong Chinese trade. Some of the lines which seem to have a special

opportunity at this time are men's clothing, clocks and watches, jewelry, pictures, groceries, especially tinned goods. There is an unusual field in China for the development of life-insurance business. The same holds true for drugs and chemicals. Japan is flooding China with cheap patent medicines and unscrupulous imitations of standard western drug specialties, and prepared food. The Chinese eagerly buy such articles because they are advertised as western and because western medicine has a high reputation with the people. If the American public, in spite of the educational campaign of the American Medical Association, and of numerous newspapers and magazines, is still unbelievably gullible in the matter of patent medicines and sure cures, small wonder indeed if the Chinese, with his ancestral regard for learning and belief in the truth of what is printed, should eagerly swallow any concoction if only it be properly advertised. But the legitimate drug and specialty business has a lucrative and valuable field in China, a field of education as well as of exploitation.

China is important to America because of the constant problem of oriental immigration. Discrimination in immigration restriction is neither just nor practical. Yet it certainly is most necessary to exclude coolie labor, whether it be Chinese, Japanese, Hindu or perhaps even Mexican. As has been said elsewhere,[1] the test of a desirable immigrant is his ability to amalgamate and become a true American. As a general thing this test excludes from the desirables the oriental coolie class. So far, no solution of the matter has been found. A so-called "gentleman's agreement" with Japan has worked probably because Japan wants every possible Japanese in Mongolia, Manchuria and China. Absolute restriction of the Hindus runs against the difficulty of their British citizenship. Yet Canada excludes them. Canada and Australia have this same problem. A new and frank immigration law is needed which shall establish a feasible and unpartial basis of admission. At present and in the near future the Pacific immigration problem is of no small magnitude.

In an indirect way China is important to America because Japanese-American relations may conceivably be strongly influenced by the policy followed by America in China. This will be taken up in connection with Japan's present activity in China. The proposed release of the Philippines will bring into prominence Japan's attitude of menace or benevolence, according to the viewpoint, towards both the Philippines and Hawaii. It seems indisputable that Japanese desire for these island territories will be inversely proportional to her opportunity for colonization and exploitation in China. A policy on the part of America which limits Japan's intentions and desires in China

[1] "Immigration and the Public Health," *The Popular Science Monthly*, October, 1913.

may therefore easily reflect those intentions in more concentrated form toward the Philippines and Hawaii.

In the present chaotic condition of internal affairs in China it is manifestly impossible to give any clear idea of what is really happening, and much less as to what may or is about to happen. A few items, however, stand out with reasonable clearness either because they are in more or less historical perspective already or because they are what might be called Chinese principles of politics. Political life in China is and always has been apparently characterized by excessive graft together with what is perhaps the truest democracy on a large scale that the world has seen. For China has given to her sons equal opportunity for advancement and moreover has made their political advancement dependent on intellectual attainment. This may not be so admirable in practise as in theory, but that is no fault of the theory. Here as always they are fond of paper reforms and platitudinous platforms which express lofty and eminently correct sentiments and which the least of them has no real intention of carrying out. The few men in China who have honestly attempted to put the paper reforms into concrete terms have stood out as heroes, to be sure, but have usually been effectively and promptly squelched.

The omnipresent and customary graft is one of the greatest evils in Chinese politics as it is perhaps the hardest to uproot. It is to be reckoned with everywhere and always, and even to a greater extent than in our own fair land.

The present political situation revolves about the struggle to introduce republican principles and a democratic electorate. To condense the exposition it may be said that the desirability of a republic in China is far from proved. Any government to be successful must be an evolution and not an importation. China's proper government must be worked out from her own history and present needs and the experience of other countries must not receive too much weight because their problems are essentially different. The average Chinese is not interested in public life, nor has he until very lately had even a sentiment of patriotism. Even now this latter is a puny thing and conditions must change considerably before China will be able to want or demand a representative government. It is questionable, moreover, whether such a government is best suited to Chinese or even oriental interests. Considering the nature of the people and their history in the light of their present economic status, a limited monarchy administered with a strong hand and insuring centralized authority and personal security with eradication of the all-prevalent graft, seems to offer the best solution.

Turning briefly to China's political relations at present, the most important for herself and the world is of course her foreign relations.

More, perhaps, than in any other country do foreign nations control her destiny. As she does to-day, China has always referred to herself as the middle kingdom, and all other nations have been barbarian to her and semi-civilized. But she has been brought along the hard path of experience to see that her very corporate existence is dependent on others than herself. In the effort to save herself she has elaborated the famous policy of playing one opponent off against another to her own advantage or more often to a simple postponement of the day of reckoning. China's relations with foreign powers have been far from convincing her that their desires are for her own good. In the old legends of the land, the devils were conceived as pale fierce beings of large size and malevolent action. Then the foreigner came along and systematically lived up to that same picture. He earned for himself the title which has persisted, of "foreign devil." As China knows to her sorrow, such he has too often been.

First among the nations with which China is concerned is to be noted Japan. Here is a long and contradictory story running back even to the time when Japan took her letters and arts bodily from China. The same process is seen in Japan to-day, and not only China, but also other nations are the losers. Robbed of the fruits of her victory over Russia, Japan has perforce had to wait the day and the strength to reach her goal on the mainland of Asia. That day seemed to have come with the European conflagration, and she at once declared war on Germany and took possession of the well-developed district of Kiaochow. The English helped with the actual occupation, but for their pains received only a contumelious eviction as soon as the eyes of the world were turned back to Europe. Having her three great allies and, as she well knows, her three potential enemies, England, France and Russia, more than occupied at home, and their attention and arms withdrawn from far Asia, Japan proceeded to put into execution a bold and barefaced robbery at the point of the bayonet of what China alone could not adequately defend. Having no other antagonists to play off against her, China could only protest and, as gracefully as possible, submit to the usurpation of her political and industrial if not even of her territorial integrity. The demands by Japan in the early months of 1915 attracted some attention at Washington and drew a response in no uncertain terms. In its note to the governments of China and Japan, the United States government said, "that it (the American government) can not recognize any agreement or undertaking which has been entered into or which may be entered into between the governments of China and Japan impairing the treaty rights of the United States and its citizens in China, the political or territorial integrity of the Republic of China or the international policy relative to China, commonly known as the Open-Door Policy."

When she extirpated the Germans from Shantung, Japan stated unequivocally that the act was a temporary measure alone and that it was merely preliminary to the restoration of Kiaochow to the sovereignty of China. Having effected her occupation this worthy purpose grew dim in the expressions of Japanese policy, and she now subscribes herself without a blush and with full assumption of justification as the successor to all the rights of Germany in Shantung. A mere recital of the demands made upon China by Japan is enough to prove our contention, particularly if the treaty relations between Japan and America, and between Japan and England, be kept in mind, as also the fact that these demands were made secretly and after withdrawal of one group following the American note, at the point of the bayonet. Japanese troops were sent into China and the direst consequences were threatened if China did not accede by the expiration of the ultimatum delivered at three in the afternoon of May 7, 1915, and which expired at six on the afternoon of May 9.

The first group of demands concerned the transfer to Japan of all German rights and influence in Shantung, with right to construct a new railroad and to prevent the entrance of any third power into this province. Group two required recognition of a specially favored position for Japan in South Manchuria and eastern Inner Mongolia. The third group looked to the eventual control of the Han-Yeh-Ping steel company by the Japanese and the exclusion of other nations from mining privilege in the general district of these mines. Group four agrees "that no island port or harbor along the coast shall be ceded or leased to any third power." Group five provided for the employment in the Chinese government of influential Japanese advisers in political, financial and military affairs, for the right of Japanese to police certain cities in China, number and names not specified, for special and exclusive privileges of railroad and other development in the province of Fukien and for the purchase or manufacture in Japan of a majority of war munitions needed for Chinese arms. The net result of these demands would be to make China a protectorate of Japan, destroying her own sovereignty and at the same time excluding all other nations eventually from developmental and industrial rights in China.

In return for all these concessions not one item of advantage for China appears, but all redounds to the very evident advantage of Japan. Certain of the demands were dropped after receipt of the American note and protests from European powers. Japan now occupies a very critical position both for herself and for China. What will follow the settlement of the European war is as yet hidden in the future, but Japan will doubtless not be left alone in her effort to Indianize China. While her hands and people are full with their present expansion in China, there is of course no probable chance for Japanese interests to require

hostility to the United States. When she is limited in her Chinese campaign and especially if the United States takes a hand in the limitation along with the other powers, it is logical to suppose that the United States will have reason to look carefully to her own Pacific coast and island possessions. If the judgment is to rest on what she has done in the near past, then the one consideration which will move Japan is her own interest and when that runs athwart the United States, let the United States defend herself.

It is said with truth that the Japanese administration of Korea has resulted in marked economic, industrial and social improvement in that country. It is added that similar administration of China as desired by Japan would be a similar advantage. This is, however, only one side of the question, and ignores the inherent right of any race or nation to work out their own development if they can. A Japanized China is not the ideal wanted by the Chinese, who have racial pride and ambition. If Japan gave any assurance that her rule in China would redound primarily to the benefit of the Chinese the position might be more tenable. At present it is not even plausible. If China will do as she has attempted to do in the matter of reconstruction and social development of her people, she has a right to work out her own lines of advance as well as her own government.

So far America alone among the nations has shown any disinterested regard for China. America alone has not assisted at forcing the principle of extra-territoriality on China. America has won a tremendous influence in China and for the taking can have a wonderful trade and industrial expansion in China, and this expansion will be under the control of the Chinese and will not limit their sovereignty or national integrity. So soon as China can produce a generation of strong high-principled men, of whom she has now all too few, so soon will she prove her ability to conduct her affairs with credit to herself and benefit to her citizens. She needs advice and assistance from foreign nations, but she does not need foreign aggression and rule. If such a generation can but be achieved, before her weakness is too far exploited by Japan, she will rule in her own land with justice and power. And the same applies to the European powers as to Japan.

A review of economic conditions in China which shall be given with comprehensive accuracy, would require a volume. In discussing it, however briefly, the point of view must be that the Chinese are essentially a secular race, lacking in the introspective contemplative traits of India and inclined rather to matter-of-fact, prosaic, tangible matters. The Chinese are industrious and minutely absorbed in the common daily round. As a race they have no outlook, no hope for the future, no interest beyond the very natural desire to secure enough rice for one more day.

The population of China is by common agreement fixed at four hundred millions. This figure rests on a singular absence of definite data. A really careful head census taken by the police in Changsha in 1913 gives some light on the subject. The population of Changsha had been estimated at from three hundred to five hundred thousand. The police census showed 270,000. It is probable that in country districts the discrepancy between estimated and counted population would be even greater. Judging from the opinions of various foreigners widely traveled in China, the ordinary estimates would be reduced to about two thirds. It is not possible here to go into extended details regarding the population of China, but there is good reason for assuming that the actual figures are not more than two thirds those usually stated.

Another common conception which does not well bear close inspection is that China is grossly over-populated. If the available possibilities of adequate forestation were developed, new industries connected with lumber supply and utilization would populate large districts now unused. So too manufacturing and factory development would employ and support a large new population. The development of water power and of the large and practically untouched mineral resources of the land, and the extension of modern means of transportation, would provide vast new employment and make possible a much denser population. There are extensive tracts of rich bottom land along the great rivers which, because they are subject to periodical overflow, are not now available for cultivation. Forestation plus reclamation works will open these to settlement. Even vaster tracts are not utilizable because of their aridity. Here irrigation projects or dry farming or such industries as stock raising await introduction. Although the Chinese farmer understands the rotation of crops and is an intensive expert, still even here is room for improvement and often rice land could be planted to corn, and its food production increased several fold. These are but the more obvious lines which will combine to make possible a vastly greater self-supporting population.

Even the passing traveler in China is impressed with the all-enveloping and well-nigh universal poverty. In the police census of Changsha the total population by count was 270,604, including 583 foreigners. Of these 52,744 were classed as extremely poor, requiring some help from the government practically all the time to prevent actual starvation. An additional 67,687 were classed as moderately poor, requiring government aid in such emergencies as flood, short crops and drouth to prevent starvation. These two classes combined represent 44 per cent. of the total population which regularly each year requires some aid to avoid starvation. And Changsha is among China's richest, most powerful and most cultured cities.

No small contributor to China's economic problems is her woeful

lack of inter-communication. Each district is more or less isolated and insolated. Only now and in the larger cities are telegraphs, telephones and newspapers seen. Traffic and commercial exchange are limited. This with the exceeding poor development of her natural resources keeps China poor, makes even the present population excessive under present conditions, and forms a vicious economic and social circle by interacting with her monetary system and lack of national stamina.

Wages are cheap, of course, but human life and labor are cheaper. Life has a fairly definite monetary value and is vastly cheaper than such western inventions as machinery, sanitation and efficient methods. There is no argument appealing to the Chinese for change when human life and labor do the work of, and cost less than, machinery. China is characterized by the lack of a genuine monetary system. Reform of the present hodge-podge of standards, exchange and discounts is always bitterly opposed by the banks and swarming cash shops which fatten off the present agglomeration of exchanges and monetary standards.

For the Chinese China is a land of tremendous insecurity of life, property and savings. It is difficult for a foreigner to appreciate how extreme is this insecurity. Life is menaced by unrestricted disease, epidemic, endemic and constitutional. There is small protection against accident, calamity, public and private foes. Property is menaced by inexactness of title, uncertainty of tenure, public accident and calamity without redress, and by the changeableness of political conditions. Insurance is a new item which for the average Chinese as yet has no existence. He patronizes all religions with careful impartiality, half consciously hoping somehow to safeguard himself and his property. His religious zeal, which frequently embraces Mohammedanism, Taoism, Buddhism and Confucianism, and too often Christianity at the same valuation is apt to be a mere form of fire insurance, with no hope other than that, if there be opportunity to escape calamity, he may perchance by this means find it.

The psychology of the Chinese is yet to be written. Such a work based on careful laboratory studies of reactions and manner of thought, would doubtless go far to dissipate the idea that the Chinese are essentially different from other people. Kipling says the obvious thing when he states:

> **Oh east is east and west is west, and never the twain shall meet,**
> **Till earth and sky stand presently at God's great judgment seat.**

But he goes further and says the true thing when he completes the stanza:

> **But there is neither east nor west, border nor breed nor birth,**
> **When two strong men stand face to face, tho' they come from the ends of the earth.**

So too there is but a temporary and partial truth in Kipling's further words, when he says:

Now it is not well for the Christian to hustle the Aryan brown,
For the Christian riles and the Aryan smiles, and he beareth the Christian down.
And the end of the fight is a tombstone white, with the name of the late deceased
And the epitaph drear, A fool lies here, Who tried to hustle the east.

The east can be hustled and the Aryan does not always smile, and there is a common meeting ground which is advantageous to both. The Chinese are very much like other people, and that they seem different at first contact often reflects merely the greater real difference of their investigators. They have the same emotions, the same joys and sorrows, and the same instinctive dislike and suspicion of what is foreign. Under the same environment conditions, or in response to the same direct stimuli, their primitive reactions are the same as those of western people. We can see mirrored in them our own mental processes and intuitive reasonings. They are more adept than we in concealing certain emotions and therefore have justly earned the sobriquet of bland and childlike. Yet in other things where we are blasé and sophisticated and indifferent, they are alert, eager and frankly interested. Few of the traits or epithets which we so jauntily and even superciliously fasten upon the Chinese, can not with equal or greater justice be applied to ourselves. It is simply a matter of hereditary perspective.

Assuming without detailed comparison that the difference is a separation in degree and not in kind, in externals and not in essentials, in practical application of principles and not in fundamental methods of thought or action, let us see in more specific fashion in what this difference consists. To understand the Chinese, one must understand their heredity and their environment. The latter can never be understandable except through personal contact, and the former may only be approached through the latter. Had we been born under like conditions and surroundings, our ways would be their ways. To have some understanding of these determinative factors, is to see how logically they act and how characteristically they react. If it is true for us that under the circumstances existing at a certain moment, a man *can* act only as he *does* act, it is much more true of the Chinese, with whom the power of tradition and custom to control action and thought is nearly absolute.

It is hard to appreciate the complete isolation of the life of the average Chinese. The coolie and the farmer to a particular degree, as well as their countrymen of more education and wealth, lead a life remarkable for its narrowness and insulation. Lack of community interest and poor means of local and general communication increase this condition. The man is content to pursue his own little individual daily round doing the same trivial things over with monotonous repeti-

tion as his father did them before him, never seeing ahead of his nose and having his nose effectually buried in the depths of monotony and covered over with the paralyzing weight of custom. His little horizon is narrowly circumscribed by his daily occupation and his constant struggle to get enough rice for to-morrow. Further than that he does not look, nor does he want any extension of his interests or limitations. He is busy, satisfied and smugly convinced that what has been always will be, and that no improvement is possible or necessary. In fact he can not and does not recognize the constriction of his own interests and personality. So acute is his struggle for actual life and so narrow the margin of safety from actual starvation, that he has no outlook beyond his own little plodding zone. He has no newspapers and no means of knowing what is going on in the world or in China or in his own province and city. Moreover, the average farmer and coolie can not read. There are no libraries or other means of diffusing knowledge. Even inter-communication by travel has made but little headway, and so we find the average Chinese shut into a monotonous round, with few holidays, no Sundays, and very rare breaks in the unchanging routine. Here is provincialism at its acme.

With this narrow and limited outlook on life, it is small wonder that superstition flourishes and that the spirit world should assume influential dimensions. The throngs of pursuing devils are always malevolent, always require appeasing and are very uncritically regarded by the people. The streets are always crooked with many sharp turns and jogs because the evil spirits proceed only in straight lines and thus can not follow one far along the street. So too the numerous gates through which one must always have an indirect approach to houses serve the same function. And the gods of the gate—those two famous old generals, Hah and Hoong, who once saved their monarch from the onslaught of a hundred thousand devils, and therefore can do the same for every household. It never occurs to the Chinese to consider whether his neighbor who neglects these observances fares better, worse or the same, at the hands of the spirits. No, here as always he is uncritical and accepts implicitly the apparent authority of tradition and custom. Not his to question, but in his characteristic matter-of-fact way, he will follow all the superstitious observances of his fathers with unquestioning faith—or indifference.

The boatman paints eyes on the bow of his craft because without eyes no creature can see. At every turn the all-powerful geomancers are consulted and by their curious processes of divination are decided favorable times and places for burial, building, wedding, journey or any other matter under consideration. If no auspicious place of interment is available or if the dragon of the earth is sulky, the deceased will be kept as a member of the household, it may be for several

years. Parenthetically it may be said that the dead are placed in huge coffins constructed of thick logs with planed sides, and after addition of quick lime the heavy lid is fitted tightly on. Such a sarcophagus may often be seen, serving as bed or table for the family until the geomancers find the season and locality which are favorable.

Every Chinese city of consequence has in the course of its years accumulated one or several pagodas which have become a typical feature of Chinese architecture. The pagoda has various explanations, but none perhaps better than that it constitutes a structure devoid of human use and intended to ward off from the city or village the baneful influence of the dragon of the air or earth. The pagoda is set in a commanding location. It has no means of ingress, sometimes indeed is built solid. How it acts no man can say, but as people even in America are not prone to defend their superstitions, so the Chinese is willing to let explanations go and assumes tacitly that like the great black arts of geomancy, this thing too is necessary for his peace and happiness.

When in 1914 the first aeroplane was about to fly from Hankow, 200 miles up to Changsha, it was necessary for the governor of Hunan Province to issue educational posters and a proclamation warning the people of the nature of this new thing and explaining that it was not the dragon of the air or an adumbration of pursuant calamity. Otherwise riots and far-reaching disorders might have arisen.

A native funeral, decked in white and carrying a parade of images of houses, men and animals, is a strange and bizarre spectacle. Then at the grave the paper and bamboo effigies are burned and furnish the deceased with property and equipment for his further adventures. Yet the canny Chinese does not burn money or houses. He unthinkingly assumes that the spirit world will be as well off for the burning of imitations, as doubtless it will. We are amused and yet the publican and the Pharisee have many an illustration in these United States. We need go back in decades only to count over the superstitions which reigned in western lands, and, even more, we find them yet. And among our most cultured and clear-thinking selves, have we raised up many phobias, and imperative fears and prepossessions which are not after all much different or more desirable than the uncritical practical superstition which rules the ordinary life of the Chinese.

It follows immediately upon their insularity and superstition that the Chinese are hyper-suspicious of all strange and new things. In this too they do not differ from western peoples. One morning an American in Changsha noted a great uproar in the street in front of his compound. On investigating, he was astonished to find a squad of police guarding his gate, all traffic stopped and the large crowd kept well back by the police. In response to his inquiry the police pointed

out a small round object lying in the street in front of the gate. It was different from anything known to them and they believed it some sort of deadly explosive designed for the destruction of the foreigner. With a guilty conscience and despite the protestation of the police, the American gentleman picked up the round object, which was a wornout atomizer bulb thoughtlessly thrown into the street the night before.

It is hard to differentiate much or most of the religion of the people from superstition. The omnipresent spirits are strangely always considered evil. Cats are held in superstitious regard and great esteem. Even yet, is it widely believed that the foreign doctor uses eyes and other organs for his medicines. Not long ago a curious group of guests, after having been taken on a sight-seeing tour through the home of a newly arrived missionary in Hunan, asked particularly to see the eyes and hearts in the covered jars in the food cellar. In spite of their excessive suspicion of all that is new and strange, a trait which incidentally is purely instinctive, they have never sought voluntarily to replace superstition by knowledge in a systematic fashion.

Closely allied to their ultra-suspicion is their ultra-curiosity. Most races except the more blasé exponents of western civilization, show great curiosity regarding foreign races. The Chinese even exceeds in this.

Their sense of humor is likewise highly developed. Laughter is never far distant and a joke on themselves is always appreciated—at least by their fellows. It is always easy to get a street crowd laughing. Little things amuse them. They are usually cheerful and happy and impress one as being content. The divine seed of discontent in fact has been smothered by their isolation and ignorance. Yet they are a laughter-loving race and it takes but little to arouse this healthy propensity.

By iteration it has grown into the western Chinese tradition that the Chinese are less sensitive to pain than western races and that their passivity and oriental slowness endow them with a nervous system different from ours in its manner of action. Such, however, is not the experience of all who have worked medically in China. They are keenly sensitive to pain and are even more appreciative of its relief than westerners, because they have no expectation of relief, and therefore appreciate it more highly. Chinese medicine has no provision for controlling hemorrhage or pain except with opium. This, with a total absence of knowledge concerning bacteria and sepsis, has made surgery impossible and has retarded the development even of an empirical medical practise. Centuries of acclimatization to suffering, however, may lead to a stoical endurance and continued expectation of suffering. And such we find. But the quick and impulsive appre-

ciation and gratitude when pain is relieved or prevented, effectually routs the idea that the Chinese has a decreased sensitivity to pain.

This brings up the question of the nature of the stoical and indifferent endurance of the Chinese race—of their lethargic inertia and apathetic acquiescence in whatever is. It is to this quality that they owe their racial preservation and integrity. It is their chief asset of strength as in it is their greatest potential fault. This it is which has time after time made them conquer their conquerors. This it is, either cause or result, which can not be dissociated from their history, their system of education and their characteristic reactionism. Yet, as has been described, when one studies the Chinese closely, he finds him quick to see humor, emotional, sensitive, reacting to stimuli much as a western man with similar environment and inheritance. In medical work among the Chinese we find neuroses, functional insanities, hysteria and minor psychoses equally or even more common than in America.

It seems that the Chinese typically has a higher threshold of stimulation than the occidental. It takes a larger summation of stimuli or a greater single stimulus in the first place to rise into consciousness and in the second place to cause reflex activity. So we see him impervious to noises, odors and sights which western nerves bear but poorly. We see him existing with no complaint and no idea of betterment in squalor, misery and poverty, which western personality would find at once unendurable. We see him exercise a fatalistic indifference to the immediate or remote future, because no clear picture has risen into his consciousness of any condition or time different from his own immediate present. When the summation or single stimulus is sufficiently great, however, for sensation to appear in consciousness, there is but a narrow margin of normal response before the reaction becomes pathological. Hence it is that all the psychoses and neuroses are so easily aroused, since the zone of normal response is narrowed by the high threshold of stimulation. Thus we see the superficial anomaly of sluggishness, inertia and indifference associated with a high and poorly controlled emotional nature which involves and easily goes over into hysteria and various emotional crises. One must indeed pause to consider the result of the impact of the hurrying din of western civilization on a racial mentality so constructed, unless indeed, as seems likely, this very inertia will rise as an instinctive protective reflex and modify the intensity of the impact by distributing it over several generations.

The Chinese are essentially, first, last and always, a peaceful and timid people. They do not take kindly to militarism and their ideals are not ideals of martial prowess or physical valor. Their invasions have been peaceful, unobtrusive and correspondingly effective. They match industry, endurance and a low value of life and living against

the sword, the intellectual pride and the standard of achievement of the west, and they win out. They do not wish to be an army, and the present effort to arouse popular admiration for the army goes counter to the ancient prejudice, which put soldiers absolutely at the bottom of the social ladder.

When White Wolf and his bandits were operating in northern Hupeh, there was great fear and excitement in Changsha, some 300 miles south, and this despite 3,000 well armed police and 3,000 northern troops and a populace of near 300,000. But the gates were doubly barred at sundown, strict search was made of every sedan chair and rickshaw entering the city, and altogether this distant and rumor-magnified bandit became a terror to one of the first cities of China.

Illustration alike of Chinese reasoning and war-instinct is found in the story told of the northern general commanding Nanking at the time of the first revolution. Nanking is situated in the hollow of a sweeping curve of the Yangtze Kiang and on the river side is sheltered and dominated by a line of low hills. The defense of these hills made them well-nigh impregnable to assault from the water way. The revolutionists accordingly landed beyond the hills and attacked the undefended rear of the city. This was entirely unforeseen by the commanding general, who promptly surrendered, saying there was no use in opposing men who took such unfair advantage and who insisted on fighting in a fashion and on a front for which he was not prepared.

But the unwarlike habit of the Chinese extends likewise to his personal relations. A domestic or street imbroglio is frequent, perhaps because of its safety. The combatants never come to blows. They may occasionally scratch or tear the hair, and their attitude and gestures will be most menacing. Yet nothing is less desired than to injure the opponent. To terrify him and make him lose face is the great object. Thus too did the old-time soldiers put on tiger skins and paint frightful figures on themselves and on their banners. The private combatants too make use greatly of judicious cursing, starting with their opponent and carrying the matter back through preceding generations to primeval times. A certain unscrupulous foreigner was wont to receive marked attention and deference from his servants by the stratagem of reciting the English alphabet with proper tone and gesture. The effect was edifying as the procedure seemed to smack of strange and powerful foreign curses, which to unaccustomed Chinese ears had portentous meaning. One never forgets such an example as a street ragamuffin meeting a distinguished and handsomely attired old scholar and incurring his wrath by some cosmopolitan trick known to the freemasonry of youth. Then the gamin and the scholar go each on his several way, each in turn at the top of his lungs imprecating the other to the original generation, and calling down on him the wrath of devils and men impartially.

They are indeed a peculiar people, these celestials, and, granting them their true apportionment of the homogeneity of the human race, yet the expression and the practise of it differ amazingly. Put a man under the Roentgen screen, and his appearance takes on a startling caricature of that same appearance in the light of day. So the oriental and Chinese illumination of human nature differs strikingly from the occidental. Thus the Chinese puts on his hat and tips his spectacles as a mark of respect or recognition. He bows in a really graceful attitude and shakes his own hands. He mourns in white, and red is his wedding color. His men wear skirts and his women trousers. The latter bind their feet instead of their waists. The men substitute for what Professor Ross calls the "diaphragmatic bellow of western males," a thin nasal falsetto singing voice.

The coolie uses a mattock and basket instead of a shovel. He pushes what we pull, and from antiquity has used the principle of the wheel, inclined plane, endless chain, water wheel and lathe. We are taking back to their originator our spectacles, printing, gunpowder, compasses, and numerous mechanical inventions. He has not and does not improve on the original methods and the primeval ideas may be observed to-day as laboriously followed out in the descent of generations.

The Chinese is just as antithetical in his mental as in his physical processes. He sees things in a different light from what we do, and his process of reasoning seems often to come out by the same door at which it went in. Still it serves him to live by.

Being oriental, the Chinese has a wonderful gift of color and music unrelieved by the softening influence of perspective, spectral relationships of color, shades or physical harmony of sound waves. He outcubes the cubists, and his dissonances, minors and falsettos are at once the despair, the malediction and the envy of western artists. The flute or wandering violin of the blind beggar becomes, with its simple and truly plaintive minor phrase, emblematic to the appreciative ear of the unconscious or subconscious racial longing for something which their history, their religion and their society have failed to give them. The chant of the drilling soldiers as toward sundown they join strongly in the new national hymn, rises with peculiar beauty and with peculiar pathos among the old hills and graves, the mud houses and ancient walls, the lethargy and prosaic level, both spiritual and physical, of the surrounding country-side. One hears this chant rising and falling with the wind, sung full-lunged and with abandon, and it sets the blood atingle with a wonder as to what the Chinese giant will really be and do when he really awakes.

Many features of Chinese social life have been dwelt on to the point of familiarity by many observers of it. The peculiar food customs,

habits, language and family organization are well known. The subservient position of women and its evil results on society have been dwelt on repeatedly. The respect for age and the authority of tradition are two potent causes for China's standstill, and themselves result most likely from her unique educational system, in turn a product and corollary of Confucianism. All endeavor and thought is concerned with the past rather than the future. This is coupled with a typical resignation to existing circumstances which, because they have long existed, does not recognize that they can change.

After all, the real interest of the Chinese for us lies in their seeming strangeness and our ignorance of their characteristics. And the essential problem, after all, to which all other problems are ancillary, the vital problem which actually innervates and pervades all our speculation and curiosity, is easily and simply stated. Is the oriental type of civilization more to be desired than the western, and when the two come into competition, which will win in the long run? Made specific, we seek to find those essential factors in the Chinese, and to deduce these from all available data of him and his ways, which shall explain to us precisely where, when and how he may become a dangerous competitor in any line of our activity. To eliminate race prejudice from such consideration is next to impossible. And yet prejudice *per se* is no evil thing. For, if it is based on just and true convictions, it is the prime necessity for moral strength in man or nation.

If then race prejudice is, as we believe, an instinctive racial protective reflex looking to the preservation of the race, and with it all of its ideals and contribution to human life, then is it a good thing and we are justified in our prejudice as the Chinese is in his. This view in no wise antagonizes the fullest expression of altruism and human interchange of wares, ideas and civilization. It says flatly: "America for Americans and China for the Chinese." Let the Chinese work out their own salvation, as they must of necessity do if they are to be saved by it. Let the west teach them western ethics, western science, western religion. But let not the strong and good elements of either civilization blot out the other until that other people shall consciously decide to change.

What then is the special element in the Chinese which arouses this strong prejudice in the western mind and is there just reason for the prejudice? This element is without doubt the enduring indomitable vitality of the Chinese race. We express it when we say that the Chinese laborer can under-live the Caucasian laborer. It is to be traced running like a thread through all the maze of Chinese characteristics. If eight out of ten Chinese infants die where three out of ten western infants die, then, as Professor Ross points out, the destruction of the weaker on such a scale must perforce mean the constant survival of a stronger, more vigorous stock, and this process continuing through centuries must give a rare racial vitality.

But this only tells one side of the story, and on close observation even the smaller side. We must remember as a corollary that while the strongest of each generation will live, they will be weakened by the struggle, and the acquired weaknesses will have the same tendency to hereditary perpetuation, as the inherent hereditary strength. Thus we are or may be reasoning in a circle. The argument of Professor Ross thus misses by far the force of a syllogism. Then too, granting a possible measure of truth in this position, the question is most apposite, is the endowment of racial vitality attained worth the ruthless sacrifice entailed, and here again we are squarely up against the relative merits of eastern and western civilization.

But it is possible that a different emphasis will reveal a more potent cause for the physical vitality of the Chinese. This too is noted by Professor Ross. The centuries of constant exposure to infectious agents have no doubt brought a gradual racial immunization to disease poisons with a consequent vitality which is not possessed by other races under like conditions. We have of course many common illustrations of such racial immunization. The attenuation of the virulence of epidemic disease and its storage in as yet ill-defined reservoirs until a less resistant generation shall permit its re-extension, is illustrated by the great waves of plague which have inundated the earth periodically. The resistance to tuberculosis of those habituated to its presence is evidently not shared by the Esquimaux and South Sea islanders. Immunity to mosquito and vermin bites which comes from long habituation is another of innumerable cases in point.

We have however to compare the Chinese vitality with our own, for example, and to continue the reasoning of relative racial immunization to disease as well as to unsanitary and low-scale living. Tuberculosis is the greatest disease plague of China, as it is one of the greatest in the west. Next to tuberculosis rank the venereal diseases. Closely following are the parasitic water-borne diseases as the typhoids, dysenteries and cholera. It is hard indeed to trace any acquired or inherited lack of susceptibility to these in the Chinese. They are undoubtedly as common if not more common than in the west. In fact, practically all of our western diseases flourish luxuriantly in China and usually claim a mortality higher than with us. China also has many diseases which are not found to any extent in the west. These are bald statements, but are based on a short experience and a longer study of available data and can only be refuted by such exact and controlled investigations as have not yet been made.

It is commonly said that diabetes is unknown in China, yet a recent incomplete investigation brought to light over 200 cases. Nervous diseases are accounted rare among the Chinese, yet even a short experience has shown their incidence, at least in Changsha, to be as great or greater

than in this country. The idea of easy child-birth and freedom from puerperal and post-partum infection is contrary to much experience and certainly is not supported by the Chinese aphorism that a woman in labor has one foot in the grave. The group of neuroses, functional digestive disorders, gastric and duodenal ulcer, malignant, nutritional and constitutional diseases, are without doubt vastly more prevalent in China than accredited to be. So we might go through the list. The point of the matter is this. We must challenge every statement of a superior racial vitality in the Chinese on the ground of superior resistance to disease, until such time as demonstrable scientific proof and controlled statistics are presented in its favor.

In determining any unknown proposition, we are safest in assuming the most probable explanation, in using analogies from our own experience, and further in checking our hypotheses by careful first-hand impartial observation.

Two points further must be briefly sketched before we can arrive at a conclusion of the matter. In the first place it is illogical and misleading to consider the Chinese a unit when we observe the influence of physical characteristics on their racial vitality. The overwhelming bulk of western medical experience with the Chinese has been with the rank and file of the coolie and farmer class who represent the lowest stratum of Chinese living, moral and spiritual as well as physical. Their existence is a mere vegetation and no accurate data are to be drawn from comparing their properties and characteristics with average western properties and characteristics. The two races must be compared class by class and the highest with the highest and not with the lowest. The European peasant or American miner will show the same stolidity, indifference and insensibility as the Chinese farmer. Medical experience with the different races coming to Ellis Island shows a surprising parallel to similar experience with various strata of Chinese society. The subject is large and needs elaboration. Here it can only be recommended for considerative development.

The second point to be remembered, while it does not concern directly our judgment on the question of racial vitality, yet bears much on our estimate of the Chinese. A strenuous competition for survival may be granted for argument's sake to improve the racial stock, though this is not conceded. Still, granting that it does, by the same rule it may well draw so largely on the last reserves of physical strength as to leave neither strength nor ambition for spiritual or moral development. In other words, we may consider that the Chinese has such a time of it supporting mere physical vegetative existence that he has won his increased stamina and ability to endure adverse conditions of hygiene and society, at the expense of his actual ability to raise his mental and moral level. This is what we actually see in China where the struggle for

existence has obviously crowded out too often the very instinct for a mental life on a higher plane.

In spite of the atavistic reversion against the rule now being illustrated by the Teutons, we see our western civilization placing its standards on ideals, on a high moral and spiritual plane. Along with this as a necessary adjunct, we see a decreasing birth-rate, a prolongation of the period of individual preparation, a prolongation of the period of maturity and effective service, a social care for the weaker social units, and an enhanced value on the individual. Looking at the orient in general and China in particular, we see a civilization rooted and defined in the struggle for existence and exhibiting as its necessary corollaries the antithesis of our western ideals. Class and not the individual is exalted, and the loss of eight out of each original ten becomes of no moment.

Drawing together now all the dissimilar threads and divergent strands, is it possible to weave them into one strong cord of consistent solution of the great Chinese problem? By a process of pure induction can we arrive at a sound judgment of the Chinese character? There is a viewpoint which reconciles all the apparent inconsistency and strangeness of the matter and brings some measure of harmony. All those lines of observation which are concerned with the more fundamental reactions of the Chinese mind agree with the results of analytical study of his more complex and remote reactions. This agreement is in effect that the Chinese does not differ essentially from his western brothers. Both are human and endowed with the same variety of human nature. Their psychological reactions are the same in nature. Their anatomy and nervous responses are the same. They react identically to pathological and psychological stimuli. They respond to the same appeals, have the same emotions and discover the same instincts. Given the same surroundings and training, we should act and react as they do. In any given circumstance it is impossible that they should comport themselves differently from the way they do. In other words, the same mental, physical and psychological laws govern the Chinese and the occidental.

But still there is a difference, and if it be not in kind, it must be in degree. Though the races are fundamentally alike, none the less our same data show a degree of difference and divergence which must be accounted for and reconciled to the essential unity. The difference in degree seems evidently to come from the peculiar and unique type of civilization which characterizes China. This civilization in turn is apparently a result of her educational system, and that in turn is based on and goes back to Confucius. Therefore it may be said that on a foundation essentially like the western, Confucianism has built an edifice which is strikingly unlike western or Christian civilization. It is

fair to assume therefore that this civilization and the type of individual associated with it, can not be changed without changing Confucianism. To get down then to the essential unity of the races, to discover the real humanness of the Chinese, he must be divested of the Confucian tradition as of a garment. It is the vesture and not the man which is different. Here comes the civilizing mission of Christianity and its great opportunity.

But this in no wise elucidates the more absolute problem of the relative value of the Chinese as against the western or Christian type of civilization. Other data are necessary for this determination and the bounds of the present discussion do not expand to meet it. The very arguments which we use so far may with similar propriety be employed by the Chinese. That is, the judge of this more ultimate problem must disencumber himself from the blinding influence of nationality, race and hereditary presumption, which of necessity condition ordinary estimates of final values. He must have perspective, and this, if it can not be attained in space, must be attained in time, which means, after all, that time is the only final and ultimate judge of which civilization is the better.

INSTINCT AND THE RATIONAL LIFE

By Professor HARRY BEAL TORREY

REED COLLEGE

I

MAN is familiarly known as the rational animal. He is well aware —or can be made aware—that if $a = b$, and $b = c$, then $a = c$. And he is the only animal so far as we know who can follow even that simple process of reasoning. Reason thus becomes a recognition mark by which the genus *Homo* may be distinguished from the rest of animal creation.

Recognition marks, however, do not comprise all the characters of an individual. They may not even suggest those fundamental attributes without a knowledge of which no adequate understanding and appreciation of the individual is possible. Though all men may show signs of rational life, if only scraps and patches of ratiocination conspicuous enough to identify them as human animals, few would venture to believe that human nature is a patchwork of this sort. To confound man with the recognition mark of his rationality is to confound an elephant with its trunk, or a dog with its bark. Just as there is more in the concept *elephant* or *dog* than appears in the signs by which we immediately recognize them, so there is more in the concept *man* than appears in an account, however complete, of his rational life. Man is indeed a rational —*the* rational animal. Reason, however, is but one of his essential attributes. For man is also profoundly a non-rational animal. It is upon the significance of this fact that I would now direct especial attention.

II

It is customary to speak of human attributes as higher and lower, as better and worse; of human acts as noble and despicable, right and wrong. And it is natural that those who, living in a social order, are constantly confronted with problems of conduct, should be prone to measure all personal experiences in terms of a moral standard.

In the present discussion, however, moral values do not immediately concern us. Human impulses have many motives; and the actions which lay them bare are determined now by reasons, now by instincts, or a variety of physiological conditions, none of which may possess any moral significance in themselves. It is difficult, however, to appreciate this latter non-moral aspect of life. And that same difficulty manifests itself in contemplating the forces of inorganic nature as well. Lightning

falls upon a den of thieves. To many it is a sign from the hand of God. To others, it is a discharge of electrical energy induced by large differences of electrical potential between the earth and a cloud perhaps a mile above it. While the first interpretation centers attention upon the moral qualities of the hapless wretches who may be destroyed, the second quite neglects that aspect of the situation. The annihilation of the thieves may be socially desirable; but to explain a cause in terms of its effect is to put the proverbial cart before the horse.

Human actions, however, we do not so easily divorce from their consequences. For consequences are likely to be more tangible than causes, more effective in arresting our attention. It is easier, also, to assign causes than to find them. In the midst of a world of problems the mass of mankind devotes very little energy to the serious investigation of them. Yet we are all unsparing critics. We are judges. We think so much in terms of praise and blame. We use the latter on the whole with the more accustomed ease. Yet there can be no more reason for finding good than evil in an action if neither is there.

III

Man is, then, not only a rational animal, many of whose actions possess deep moral significance; he is also a non-rational animal, the real significance of many of whose actions is only obscured by the intrusion of rational or moral standards. It will be helpful, I believe, to consider these non-rational elements as parts of his essential nature like the rest, neither higher nor lower, better nor worse, more nor less of the spiritual essence. Human nature thus becomes, for practical purposes, a complex differing for different individuals, whose essential characteristics can only be learned through the activities which give them concrete expression. I say for practical purposes, because the value of a definition lies in its efficiency as a tool. Facts do not fit themselves to definitions. Definitions must be applicable to the facts. To define man as an animal with an immortal soul would be of little practical help in distinguishing men from dogs. For this would merely develop the need of a practical criterion for an immortal soul applicable to both dogs and men.

Similarly, it would be difficult to suggest any *workable* definition of human nature that did not involve the activities by which it is made objectively visible. This follows from the fact that while we possess a certain intimate and direct consciousness of much of our own personal lives, we can interpret the lives of others only through the medium of their actions. As students of human nature, then, we become, perforce, students of behavior.

The actor, whose chief business it is to give to mimic emotion the semblance of reality, is especially conscious of this fact. For progress in

his art depends primarily upon the choice of signs. All signs are not equally full of meaning. Nor is there a direct proportion between intensity of action and emotion. Subtleties of expression are now eagerly sought. New possibilities are boldly investigated. Even the long neglected human back has developed unexpected power to register vicissitudes of human feeling. Speech itself, the most familiar means of communication between persons, is but sign language, owing its popularity to its utility not only for wide range but great niceness of expression.

It is one thing to make a conscious sign, and quite another to receive and interpret it, as we are all sufficiently aware. Often, however, the most significant signs are given unconsciously. In such cases we may at times reveal ourselves unwillingly. At other times, our reactions, did we but note them, would reveal us to ourselves.

IV

The actions which in their totality constitute the behavior of the individual fall roughly into one or the other of four convenient groups, according as they are rational, intelligent, instinctive or reflex.

Rational behavior typically indicates a capacity to form judgments, to appreciate the meaning of *therefore* and *because,* to classify and generalize experience. The invention of a mechanical device, the solution of a problem, the prosecution of an argument, are some of the numerous examples of rational behavior that suggest themselves at once. It is not needful that the device be salable, the solution sound, the argument effective, provided only the process by which the end is reached indicates the capacities of the mind that have already been enumerated. Such indication is not always clear. A chimpanzee, for instance, draws food toward its cage by means of the crooked end of a cane. It uses a tool. If we do not choose to call these animals rational that thus adapt implements to definite ends, we may nevertheless agree that such behavior indicates the possession of mental attributes closely akin to reason in a rudimentary form.

V

Turning now to a consideration of intelligent behavior, we shall find it well exemplified in the dog. This animal does not reason, nor does he appear from the evidence at hand to be able to use tools like the monkey. He is essentially a non-rational animal. Yet he can profit by experience. He can learn. This capacity to learn has been conveniently distinguished from reason under the name of intelligence. The term is used commonly in a looser sense to include reason as well. But the distinction justifies itself when, upon analysis, we find that much of the behavior that is usually classed with rational as intelligent resolves itself into actions that can be accounted for by a merely canine capacity to learn new tricks. So much of life consists in sitting up at command,

barking for metaphorical lumps of sugar, learning to heel, and wearing a muzzle without protest.

Intelligent animals are distinctively characterized by the possession of associative memory. They are able not only to remember, but to associate different experiences in their memory. The essential part of the learning process is, therefore, the establishment in the memory of an appropriate association. That is what one must accomplish in training a dog. But one soon finds, when he engages in such a task, that he must also gain the animal's attention and direct it to the desired end. So he rewards success, or rebukes failure, until the animal shows by the precision of its response that the association between the latter and the signal of command has become definitely established. The process is the same, whatever the object; whether the dog is destined for domestic service or for the stage.

It would be interesting to digress here into a consideration of the value of punishment as a pedagogical device for enforcing attention. If there is any justification of the old-fashioned spanking, it is to be found, to my mind, in such a function.

A more immediate problem, however, lies in the query whether, after all, the dog in learning to obey his master's command, did not employ in some degree the process of reasoning. Did he know why he was rewarded or why punished, and act accordingly? If so, the evidence from this and many such experiments fails to indicate the fact; while the following investigation of the association processes in the dog demonstrates the formation of typical associations in the complete absence of rational processes.

It is well known that under certain circumstances the mouth waters, which is only a familiar way of saying that the flow of saliva into the mouth has been increased. The sight of food—even the thought of some appetizing dish—and a number of other causes may produce this result, which is in every case due to the stimulation of the salivary glands. Among the effective stimuli, one of the most convenient for experimental purposes, is hydrochloric acid, a few drops of which, under the tongue, produces a definite increase in the secretion of the parotid gland—which may be remembered as the seat of trouble when one suffers from *mumps*.

Now it is possible, by a slight operation, to divert the flow of saliva from the parotid gland away from the mouth to the exterior, so that the rate and character of the flow may be accurately observed. A method is thus obtained not only for estimating the effect of various stimulating substances upon the salivary glands, but, which is far more significant, for measuring in concrete physiological terms the processes that take place in the higher centers of the brain. Suppose, now, that as a few drops of hydrochloric acid are placed under the tongue, a whistle of a

given pitch is blown. Suppose, further, that this simultaneous application of acid and sound is repeated as many, let us say, as twenty times. Then suppose that at the next trial, the acid is abandoned, but the whistle is sounded as usual. Repeated experiments have shown that under such conditions the sound of the whistle, which at first produced no appreciable effect upon the salivary glands, now distinctly accelerates the flow of saliva. That this is an example of the establishment of a new association without the aid of reason follows from the fact that the mouth waters without consideration, as a result of reflex stimulation of the salivary glands which the animal concerned may even quite fail to notice.

The mechanical preciseness of this association is especially emphasized by the fact that it obtains only for whistles of the same pitch. Even the most trifling differences in this respect reflect themselves in the rate of the salivary flow. The association involves a particular tone, not sound in general. It is an association of a very definite, circumscribed type. It exhibits nothing of that adaptability which makes the behavior of tool-using animals so noteworthy.

Yet it is just this type of cerebration that is involved in a vast number of our everyday actions. We even make a boast of it. This man has voted with one political party so long that his dogged loyalty has become his political virtue. That man believes that the duelling code to which he has been brought up is a necessary part of the library of every gentleman. We may have learned to like figs and olives, but we still eschew horse flesh. We are assured that many of the processes by which foods are prepared for the market are irrational, but we continue to demand them. We estimate our guests by their table manners. And we give our favor to a soft falsehood, snubbing a harsh truth. We prescribe not only the canons of dress, but of esthetic taste. We know what we like—alas. We set the limits of polite conversation. We even dictate terms of thought itself. We persecute the genius who would enlighten our ignorance, because his ways are strange. We applaud the demagogue for speaking the fluent language of our own mediocrity. And we marvel at our intelligence.

The same facts confront us in the very institutions whose sole reason for existence is the instruction of the young. The earlier years of our school life are devoted largely to the training of the senses and muscular coordinations, and to the formation of new associations in language and number. Later, the persistent argument for mathematics —that it trains especially the rational powers of the mind—only accentuates the fact that in the secondary schools also a large place in the curriculum is given to studies that do not make such an appeal. The helplessness of many a college entrant when thrown upon his own resources points to the same conclusion. We may be rational animals,

but a large proportion of our formal education consists in learning, like the dog, to do new tricks.

Whatever the reasons for the prevalence of this cookbook type of instruction throughout the school system, the fact shows how conspicuously our educational methods reflect what the illustrations previously given may have made clear, namely, the important function of associative memory in the life of man. And an examination of associative memory leads us, as we have already seen, to a type of physiological mechanism that has now been partially investigated by seizing the opportunity for analysis afforded by the salivary reflexes of the dog.

VI

Those actions may now be briefly considered which are called instinctive. It will not be possible to discuss the various definitions that have been offered from time to time for the word instinct. Some are concerned with psychical attributes, some with physiological responses. Some involve genetic ideas like the phrase *inherited habits,* while others lay stress upon the adaptive value of instinctive acts in the life of the organisms that exhibit them. So many definitions have been proposed and so many criticisms of the proposals have been made, that several authors have advocated the abandonment of the term altogether, as lacking sufficient precision for satisfactory discussion. I shall not follow this radical procedure, however, for there is a definition of instinct that is not only simple but will, I feel sure, be serviceable in the present discussion. According to this definition, instincts may be regarded as complex reflexes. This is diametrically opposed to the view, still popularly current, that instincts are superhuman endowments, by means of which various animals are able to foretell events. Such feats are feats of magic. And whatever instinct may be it is not magic. On the contrary, the conception that instincts are merely complex reflexes has a sound basis in our experience, as the following illustration will show.

Let us consider, then, the feeding instinct of the common freshwater crayfish. The body of this lobster-like animal is composed of a series of segments, each furnished with a pair of appendages. The appendages are all constructed on the same general plan, but variously fashioned in accordance with different functions in different parts of the body. It will be necessary to consider now only the highly modified mouth parts and the walking appendages, the foremost three pairs of which bear pincers at their tips. Suppose a bit of meat is placed near one of the third pair of walking appendages. It will not be long before that appendage moves toward the morsel, grasps it in its pincers and carries it forward toward the appendage immediately in front. This second appendage, almost identical with the last in structure, moves backward and receives the morsel, then carries it forward to the

mouth. The meat is there seized by the prehensile maxillipeds, carried inward and finally engulfed. In these coordinated movements of the successive appendages, the movements of the one appear to initiate and control to some extent the movements of the next in the series. This is due to that fact that the appendages communicate with each other through the nervous system. The central nervous system of the crayfish is composed of a chain of masses of nerve cells extending from one end of the body to the other, a pair of such ganglionic masses sending nerves to each pair of appendages. By cutting the nerve cords connecting the successive ganglia it is possible to destroy the coordination that previously existed between the appendages to which the nerves from these ganglia are distributed. By severing the nerve chain between every two ganglia it is possible to divide the organism into a series of non-coordinated parts. The appendages of each segment react normally to stimuli, but such stimulation no longer induces reaction in the appendages of a neighboring segment. Each segment with its appendages is thus seen to be a complete reflex mechanism of nerve and muscle elements. The difference between the reflex movements of the appendages of any given segment, and the coordinated movements of the appendages of several segments which are characteristic of the normal feeding reaction of the animal is one illustration of the difference between a relatively simple reflex and an instinctive action.

The definition of instinct thus illustrated has been formulated because of its objective value. It includes no mention of the possible cognitive and emotional accompaniments of instinctive action. For, while psychic facts of this sort can be shown by direct testimony to accompany instinctive acts in man, it is quite impossible to obtain such testimony from the lower animals, in which instincts exist in their purest and simplest forms, and are most amenable to physiological analysis. And it is the latter with which we are especially concerned.

VII

It will be desirable now to indicate somewhat more fully the characteristics of reflex actions. The term *reflex* was first introduced to characterize the response of a motor element in an organism to a stimulus applied to a sensory surface that is connected with the motor element by nerves through a nerve center—such as the spinal cord of a vertebrate or a ganglion in the nerve chain of the crayfish. For the propagation of the nerve impulse from the sensory surface to the nerve center, and from the nerve center to the motor element strongly suggests the behavior of a beam of light that falls upon and is thrown back from a reflecting surface.

Since the knowledge of reflex actions was developed originally upon

organisms possessing a nervous system, it is natural that reflex action should still be associated by many with a neuro-muscular mechanism. Actions which differ in no essential particular from those characteristic of a neuro-muscular mechanism, occur, however, in such organisms as the sensitive plant, *Mimosa,* and the simplest animalculæ, none of which possesses either nerves or muscles. They occur also in many of the tissues of our own bodies which respond to stimulation of various sorts without the intervention of either nerves or muscles. One such case will sufficiently illustrate the fact. The pancreas—one of the sweet breads of commerce, and the most important single digestive gland—pours its juices into the small intestine only when a chemical substance known as secretin is brought to it by the blood stream. The secretin itself is produced in the cells of the intestinal wall under the influence of the acid which comes into the intestine with the partially digested food from the stomach. Careful experiments have shown that in the production of secretin by the intestinal walls, and of pancreatic juice by the pancreas, nerves play no part. Chemical substances acting directly on glandular tissues set up in the latter energy transformations that result in the production of the secretions characteristic of the glands in question.

The activities of many parts of the body are similarly brought into correlation by means of chemical substances or *hormones* that are carried about by the blood. Correlations of this sort exist between the ovaries and the uterine changes connected with menstruation, between the testes and secondary sexual characters of the male, between the increased production in the blood of carbon dioxide that is a normal product of physical activity, and the more rapid and labored breathing that follows pronounced physical exertion.

Further citations of this sort of reflex are unnecessary for our purpose. The cells of which the various tissues of the body are composed are all irritable, since they react to appropriate stimulation. As they all arise in development from a common source, the fertilized egg cell, the specific character of the reaction of a given cell is determined by the direction in which the cell has differentiated. A white blood corpuscle, possessing neither nerves nor muscles, itself but a single cell, receives and conducts stimuli, contracts, secretes chemical substances—exhibits, in fact, in some degree, all the properties that appear in such specialized tissues as muscle, nerve, gland, where contractility, or conductivity, or secretability, as the case may be, has been augmented out of all proportion to the others.

The more the nature of reflex action is investigatetd, the more clear is it that nerves and muscles, though conspicuous in certain of its types, are in no sense necessary to the fundamental physiological activities that

lie at the bases of the actions themselves. If this is clear, then it will be possible to suggest the important similarity to reflex action of such a well known phenomenon in the organic world as the explosive response of gunpowder to the touch of a lighted match. Reflex actions are due essentially to transformations of energy that are initiated by some sort of stimulus; and the energy changes that occur in the protoplasm of which living bodies are composed have been shown by many careful researches from the time of Lavoisier to the present to follow the laws that are familiar to the physicist and chemist.

This connection between physiological processes and chemical reactions is of especial significance for students of animal behavior; for just as chemical reactions are controlled by conditions, so the constancy of reflex and instinctive actions depends upon the constancy of physiological processes and conditions by which they are controlled. The reactions that constitute the behavior of an organism vary in this regard. Some are more stable than others, retaining a relative constancy amid fluctuating circumstances. Which are they, rational or instinctive? Reflex or intelligent? It is important that we know and know why.

VIII

In discussing the problem that thus presents itself, it will be convenient to distinguish between those conditions of stability which are in the main structural and those which are in the main functional. It is needless to dwell upon such obvious correlations as the flying and pecking instincts of birds with the structure of wing and bill, and the entire absence of such instincts among goats and monkeys; upon the connection between the breathing organs of the salmon and an exclusively aquatic life, or between the traditional sluggish movements of the snail and the peculiarities of its locomotor mechanism. Large numbers of similar instances of the limitations imposed by structure upon behavior present themselves at once. Similarly, any simple reflex that depends on the connection of sensory with motor elements by means of nerves that pass from one to the other through a nerve center, fails when at any point the necessary connections are broken. While the latter exist unimpaired, a certain stability of reaction is maintained.

Less obvious, but more intimately significant is the relation between the structure of the central nervous system and the behavior of vertebrated animals. In its simplest form, the central nervous system of vertebrates is constructed on a segmental plan, suggesting in a general way the segmental distribution of nerve centers that has already been noted in the crayfish. Among the lower vertebrates this is especially evident. In fact, the removal of the entire brain from a frog does not interfere in the slightest degree with the complicated responses of the

limbs to stimulation of a sensory surface that are characteristic of the normal creature. A drop of acid placed on its back calls forth the most accurately coordinated movements of the hind limbs directed toward the removal of the irritation; movements whose definite adaptation to that end presents a purposive aspect that is customarily associated only with conscious motive.

Even small pieces of the spinal cord suffice for similar reflexes. The embrace of the female by the male during the breeding season is due to a convulsive reflex of the arms brought about by stimulation of the skin below and between them. Not only does this reflex persist after decapitation, but even after the removal of all the body except a narrow segment made by cross cuts immediately in front of and behind the shoulders. By irritating the skin on the lower surface of this body ring, the arms can be made to perform the clasping movements characteristic of the normal frog.

In the higher vertebrates, experiments do not reveal so clearly the segmental character of the nervous system. Cats have been known to live years with severed spinal cords, but the reflexes of the limbs, thus isolated from any influence of the brain, are neither so definite nor so well adapted to useful ends as in the frog. This statement applies with still more force to the monkey; while in man, when the spinal cord is completely severed and the connection between brain and limbs thus interrupted, muscles waste away, skin reflexes quickly disappear, and even the well known knee jerk soon is lost. The parts that in the frog are to some extent isolable and autonomous nerve centers, in man have lost their autonomy and function only as parts of a larger whole.

These facts are definitely connected with the finer structure of the nervous system. In the nerve cord of vertebrates are tracts of short nerve fibers that run between segments of the same region, and tracts of longer fibers that run between segments of different regions, and between the cord and the brain. If the longer fibers account for the integrated activity of the parts which is so conspicuous in man, man should possess them in relative abundance. Man does, indeed, possess them in relatively greater abundance than any other animal. With the increased development of these longer association fibers, the higher nerve centers appear to have taken over the control of functions previously exercised by the segments of the spinal cord. Thus a new position of stability is reached through new complexity of the nervous system.

These illustrations must suffice for the present to indicate the relation between the typical behavior of organisms and their structure. Let us turn now to types of behavior that depend essentially on the stability of physiological conditions.

The respiratory mechanism, by means of which we breathe, is composed of numerous muscles acting upon skeletal elements and stimulated through nerves from the controlling nerve center in the base of the brain. If this mechanism were not automatic we should die. Yet the activity of the respiratory center on which this automaticity depends is not possible when the quantity of carbon dioxide which as a normal product of the decomposition of the tissues, is always present in the blood, falls below a certain minimum. Similarly, the necessary tone of the heart and blood vessels is controlled by the secretion that is poured into the blood from the adrenal glands. The control of the digestive function of the pancreas by the *secretin* formed in the walls of the small intestine has already been described.

From such stable, hereditary reflex mechanisms, whether simple or complex, that have been established independently of experience, Pavlov has distinguished as *conditioned* reflexes, those which, like the salivary reflex of the dog, are products of training. They are based, it is true, upon an hereditary associative mechanism, or, as we are wont to say, an hereditary tendency or capacity, but their establishment as definite associations is only accomplished through individual experience. These associations are on the whole formed readily and readily destroyed, as experiments have shown. They are accordingly less stable than the reflexes of the *unconditioned,* instinctive type. Yet out of such conditioned reflexes is constructed, as has already been indicated, the physiological mechanism of intelligent behavior.

IX

It has been indicated that the stable hereditary mechanisms which exist in bewildering variety in the human body must operate under the conditions which the environment imposes. These may be permanent, dependent, like the body temperature, upon a stable, hereditary heat regulating mechanism. Or, like changes in temperature, doses of disease toxins, alcohol or strychnine, they may be temporary, the functions disturbed ultimately resuming their normal course. The fact that reflex and instinctive actions are subject to change under changed conditions has led authors frequently to speak of instincts as modifiable. That this expression may not be misleading, it should be remembered that reflex and instinctive actions, like physical and chemical reactions, are resultants of a play of forces. And since instinct is but a name that is conveniently applied to certain complex types of reflex action, it can only be said to be modifiable, as a physical or chemical reaction is modifiable, that is, through some change in the complex of conditions of which it is a product.

Modifications of instinctive action by changing the conditions, it is

easy experimentally to induce. It will be well to select for the purpose as simple an organism as possible. Certain minute inhabitants of many a wayside pool, organisms that are commonly known as water fleas, will admirably serve. Gathered into a dish and placed before a window, many of them pay no apparent heed to the light. On the addition of a modicum of carbonated water, however, they turn with almost military precision and swim rapidly toward it. Remove the carbonic acid; they scatter. Replace it; again they congregate next the window. There is an obvious connection here between the presence of carbonic acid and the reaction of the organism to light.

The caterpillar of the moth *Porthesia* affords another case in point. In the spring it awakens, hungry, on the twig to which it has clung through its long winter sleep. Almost the first thing it does is to climb upward. In so doing, it discovers the swelling succulent bud at the end of the twig, and feeds forthwith. Having feasted, it wanders away, later to ascend another twig, perhaps, to another feast.

Nothing, at first sight, appears more purposeful than such behavior, more the result of conscious design. Yet no appearance could be more deceptive. If the position of the twig is reversed, the caterpillar crawls upward just the same. It crawls upward away from food quite as readily as it crawls toward it, even though in so doing it follows the path to certain starvation. The facts are that when underfed, it responds to the pull of gravity by crawling away from the center of the earth, and that feeding tends to destroy this reaction. And a sound interpretation of these facts is, that the substances diffusing into the body through the walls of the digestive tract modify the response of the instinctive mechanism that determines its reaction to gravity, just as—though in an opposite sense—the carbonic acid diffusing into the body of the water fleas affects their reaction toward light.

These examples must suffice to illustrate the effects of transient conditions on the relatively stable mechanisms of instinctive action. Reflexes of the conditioned type are similarly subject to control. One of the most characteristic effects of alcohol on the human organism is its depressing action. In sufficient quantities it induces forgetfulness. It weakens the power of repression. It dims the mental vision we call foresight. Under its influence men frequently talk much and loudly when silence were wiser; they lose their sense of fitness and proportion. All of these effects are due to its action as a physiological depressant or inhibitor. And the physiological mechanism depressed or inhibited in each case is a conditioned reflex, a mechanism of association, a product of individual experience.

Strychnine, on the other hand, is a stimulant. In moderate doses, it so affects conditioned reflexes as to quicken memory, clear the mental vision, enliven thought, facilitate the establishment of new associations.

Along with their influence over reflexes, whether conditioned or unconditioned—and they exert control over both—these drugs produce marked effects upon the emotional and temperamental traits that belong to what is called the *disposition* of man. In this respect, they are but two of many chemical substances whose presence in the blood stream is known to be associated with predictable emotional states. Many of these, like the secretions of the thyroid and adrenal glands, are formed in the body itself. Though it is not possible to dwell further on these facts at this time, their significance for any physiological analysis and control of psychic states cannot be over-emphasized.

X

Reflexes, whether of the unconditioned, instinctive, or of the conditioned, associational type, are controlled not only by chemical environment. They are controlled by each other as well. When two instinctive mechanisms are simultaneously stimulated, the activity of the one may *inhibit* the other, as the reaction of the water fleas previously considered to a touch has often been observed to inhibit their response to light; or, one may *augment* the other, as the reaction of a frog's hind leg to a given mechanical stimulus is augmented when a shrill whistle is blown at the moment the mechanical stimulus is applied.

Such examples are closely paralleled in the experiments of Pavlov on the salivary reflex of the dog. For not only has it been found that the slightest unusual sound may diminish the salivary flow, but that the sight of a person with whom the dog is on unfriendly terms may increase it.

XI

If the facts that have been thus far presented show that the human capacity to learn is on its physiological side a capacity to form reflexes of the conditioned type; that the associative memory can be controlled by controlling the reflex mechanism which is its physiological counterpart; it remains to consider whether the rational life of man can be connected helpfully with similar conceptions.

The difficulty of distinguishing sharply between rational and intelligent behavior has already been indicated. Among genetic psychologists, it is commonly agreed that the capacity to use tools—as represented in the chimpanzee—is a further evolution of the capacity to learn that is characteristic of the dog. And though few may be ready to grant that those animals which are capable of using tools are thereby typically rational, few are disposed to deny that such a capacity touches the threshold of reason. Reason thus appears to be but a further extension of the power of association. Whereas, in the dog, associations are formed only between objects or events related in time or space, in

the ape, the adaptation of an implement to a use involves far more complicated processes of association, and marks a long step toward the recognition of relations of cause and effect. Whether the further step to behavior of an undoubtedly rational type is longer or not must remain for the present largely a matter of personal judgment. The pertinent anatomical and physiological facts that are available minimize the difference. The cortex of the cerebral hemispheres is necessary to both intelligent and rational action. Minute and careful examinations of its structure have failed as yet to reveal any indication of separate mechanisms for the two. The influence of drugs on rational behavior is essentially what we have seen it to be on intelligent behavior. Alcohol confuses many a clever head; laughing gas, according to William James, makes folly seem like the quintessence of sense; and strychnine sharpens the wit as well as accelerates the learning process. Finally, that reasons, like conditioned reflexes, now appear to hinder, now support each other, are facts so poignant in our every-day experience as to demand no illustration.

If, then, one is justified in believing that the rational behavior of man is dependent on associational processes, rooted in and determined by physiological reflexes, man's conduct becomes interpretable in terms of those reflexes. Certain relatively stable hereditary complexes of these, existing as instincts under a great variety of forms, give character to conduct, and the essential flavor to personality. Certain other complexes, less stable, fashioned out of individual experience and rearranging their elements far more readily in response to changing circumstances, while they provide the individual with an invaluable mechanism of adaptation, define him less conclusively to his fellows. As a rational animal, man possesses an invaluable hereditary mechanism for forming associations of the most complex and general type. Through the possession of this mechanism he has become the lord of all creation. But just as it has been the essential source of his power, so it has provided him with opportunity for the most stupendous follies. As a rational animal, man is both wise and foolish.

But even as a rational animal, wise or foolish, his conduct, so far as it is subject to scientific analysis, appears to be controlled by nonrational physiological mechanisms that respond to stimulation in accordance with physiological laws. As John Dewey says,

> It is not we who think, in any actively responsible sense; thinking is rather something that happens in us.

THE FOOD PLANTS OF THE ANCIENT HAWAIIANS

BY PROFESSOR VAUGHAN MACCAUGHEY
THE COLLEGE OF HAWAII

A SURVEY of the dietary of any people affords an interesting commentary on their natural environment, on their racial peculiarities and on the relative complexity of their civilization. This statement is peculiarly applicable to the native peoples of Polynesia, because of their erstwhile isolation and because of the strongly defined influences of their tiny island worlds.

A consideration of ancient Hawaiian life clearly outlines two features of their diet that are equally characteristic of many Polynesian peoples. First, the limited supply of meat, and, second, the culture of a considerable variety of food plants. The larger meat-producing animals were unknown to the Hawaiian until the coming of the white man. Swine, dogs and fowl comprised his domesticated animals. There were no wild mammals; the chiefs hunted mice with bow and arrow, for sport, not for meat! In certain localities and at certain seasons fish and other marine animals were obtainable in large quantities, but these did not constitute any very considerable proportion of the diet of the people as a whole. Under the rigorous *tabu* system, many forms of meat were entirely prohibited from the women; and many others were the sole right of the chiefs. The mass of the Hawaiians were enforced vegetarians, as are the mass of people in other parts of the world to-day.

The more important food plants were brought by the Hawaiians in their migrations from the South Pacific. The few indigenous fruits were utilized to a limited extent. The majority of the crop plants were raised in plantations near the villages; some, like the *awa* and *api'i*, were grown in clearings in the forest, and were visited only occasionally.

The *taro* or *kalo* (*Colocasia antiquorum* var. *esculentum* Schott.) easily takes first place in order of importance. This widely-cultivated aroid and its immediate relatives are abundant in many parts of the tropics. Throughout the larger islands of Polynesia, it is still the food plant *par excellence*. It has a crown of caladium-like leaves, borne on the summit of an erect subterranean corm. The starchy corm attains a diameter of six or seven inches, and a length of one to three feet.

There are two main classes of *taro*—the "dry-land" type, which grows without irrigation, and the "wet-land" type, which is raised in irrigated patches or *loi*. The former predominated on the uplands; the latter was most abundant on the valley-floors and lowlands. The

ancient Hawaiian recognized over two hundred varieties of *taro,* which they designated by distinct varietal names. The choicer kinds were raised chiefly for the nobility, and were often spoken of as "royal" *taro.* Other kinds were used medicinally and in religious ceremonies.

The *taro* corm required about a year for maturity. It was then dug, cleaned, steam-cooked in the underground oven (*imu*), peeled and pounded into a starchy paste, *pai-ai.* In this form it kept indefinitely, and was prepared for immediate use by merely thinning with water. This constituted the familiar *poi* of Hawaii, Samoa and other Pacific Islands. It fermented slightly, and kept some time without spoiling. It was stored in wooden bowls and was eaten with the finger. Large quantities were consumed at each meal, and its starchiness was decidedly conducive to corpulency.

The succulent young leaves and petioles of the *taro* were cooked and eaten like spinach, and comprised the delicate vegetable called *lua'u.* The general use of *lua'u* at feasts caused the feasts themselves to become known as *lua'us.* The *taro* corm was also eaten as a baked or roasted vegetable, and was often mixed with breadfruit, cocoanut, sweet potatoes, and other foods. It was never eaten raw, because of the irritating poisons which were only dispelled by cooking.

Closely resembling the *taro* is the *api'i* or Giant Taro (*Alocasia macrorrhiza* Schott.). This is a large, succulent perennial, several times larger than the *taro.* The thick, erect stem rises two or three feet from the ground, and bears a large terminal crown of sagittate leaves. The *api'i* is abundant in the lower woodlands and near settlements. It occurs in many islands of the South Pacific and was probably brought to Hawaii by the first native immigrants. Unlike the *taro,* its cultivation was not carried on in any methodical manner. Small patches were planted here and there in wet places in the forest. Wooded streamways and the neighborhood of waterfalls are typical habitats for the shade-loving *api'i.* If the supply of *taro* ran short, or if there were any other shortage of food, the natives gathered, cooked and ate the coarse, starchy *api'i* stems. It was baked or roasted, and sometimes made into *poi.* Nowadays this plant is rarely used for food, but is planted for its ornamental foliage.

In quantitative importance as a food staple in ancient Hawaii the sweet potato or *u-ala* (*Ipomoea Batatas* Lam.) is exceeded only by the *taro.* The sweet potato permitted a much wider range of planting, as regards both soil and water supply, than did the *taro.* It flourished in semi-arid regions, and in the districts sheeted with lava flows. It was thus the main reliance of the natives in those regions where the *taro* did not thrive. The *u-ala* was brought from the South Seas by the Hawaiians, and was widely planted in the new island home. The natives had names for about sixty varieties and sub-varieties. Parts of Kauai and Niihau, for example, were famous in the days of early Euro-

pean exploration of the Pacific, as provisionary places for sweet potatoes and yams. Great quantities of *u-ala* were shipped to California during the days of "'49."

True arrowroot, *pia* (*Tacca pinnatifida* Forst.), has a wide distribution throughout the tropics, and is cultivated for its starchy tubers in many parts of the Pacific. It has accompanied the Polynesian in all his wanderings, and, like many Hawaiian food plants, finds its northern Oceanic limit in this archipelago. The *pia* leaves are radical, and rise on slender petioles to a height of several feet. The blade is five-lobed; the lobes are irregularly pinnatifid. The leaves appear in early spring and wither by the close of summer.

The ancient Hawaiians raised *pia* in small patches in the open woodlands and in various suitable lowland localities. In modern times its culture has been almost wholly abandoned, and arrowroot is now relatively rare. It does not appear to have become as thoroughly established as some of the other food plants, the *taro* and *hoi*, for example.

Another plant of wide geographic range is the yam or *hoi* (*Dioscorea sativa* L.), which occurs from Africa to Hawaii. This vigorous climber has a large tuberous rhizome, a long twining stem, and large cordate leaves. Greenish round tubers commonly occur in the leaf-axils. Both rhizome and aerial tubers (called *ala-ala*) were used for food. The *hoi* was formerly very common in the lower forest, and is still plentiful in many places. As indicated with the sweet potato, yam culture was greatly stimulated by the native trade with European vessels. "Yam Bay" on Niihau, for example, was a familiar entry in the log of many an exploring ship and whaling vessel in the early days of Pacific exploitation.

The native banana, *maia* (*Musa sapientum* L.), like the *taro* and sweet potato, is seedless, and is propagated solely by vegetative methods. It was undoubtedly introduced by the first Hawaiians, and is often referred to in their ancient songs and legends. In former times the *maia* was plentiful around the villages and plantations, and, like *api'i*, was also under semi-cultivation in the forest. These forest plantings gradually extended themselves, so that to-day there are many beautiful ravines and valley-floors covered with luxuriant wild banana groves. A considerable number of the native varieties were of the starchy or "cooking" type, that is, they required heating to bring out their characteristic delicious flavor. These are not to be confused with the so-called "plantains" of other tropical countries, which are much larger and coarser than the Hawaiian bananas. The natives were very fond of the banana, and it figured prominently in their feasts. In recent years the native varieties, of which there were about fifty, have been supplanted in the markets by various introduced kinds, the dwarf Chinese banana being chief of these and now dominating the markets.

In addition to the herbaceous starch-producing plants, already de-

scribed, the Hawaiians cultivated two important trees for their starchy fruits, namely breadfruit and pandanus. The breadfruit, *ulu* (*Artocarpus incisa* L.), is one of the finest trees in the Pacific. In favorable humid situations it develops a magnificent dome of large, dark green, glossy foliage. It sometimes attains a height of seventy or eighty feet, although in Hawaii it does not reach the stature of the South Sea breadfruits.

The mature fruit is nearly as large as a man's head, and comprises a leathery reticulate rind, a small stringy central core, and a large mass of starchy edible material. Upon thorough baking the interior becomes soft and mushy, and develops a pleasant taste and odor. The Hawaiians brought the breadfruit from the South Seas, and planted it extensively on the lowlands and in the valleys. The fruit is seedless, and the tree is propagated exclusively, and with considerable difficulty, by root-cuttings.

At the time of the discovery of Hawaii by Europeans there were splendid groves of *ulu* on all the islands. Like the cocoa-palm groves, the majority have vanished with the vanishing Hawaiian. Here and there in the deserted valleys, the traveler to-day finds dishevelled breadfruit trees, surrounded by foreign vegetation—lone symbols of the passing *kanaka*.

A tree that is of much importance as a food plant on many of the low coral islands of the South Pacific is the pandanus or screw pine (*Pandanus odoratissimus* L.). The Hawaiians, having other more satisfactory starch plants, such as the *taro* and yam, did not utilize the edible *hala* drupes as freely as did their southern relatives. The sweet fragrant meat of the kernel was considered a relish, a dessert, rather than a staple of diet. The rich scarlet or orange woody ends of the drupes were artistically strung into fragrant garlands. In Hawaii the long, fibrous, ribbon-like leaves constituted the most important part of the *hala* tree, as they were universally woven into mattings. The *hala* came from Samoa and is often referred to in the old chants. It is now thoroughly naturalized and abundant in many parts of the islands, and along certain coasts forms continuous groves.

The most casual suggestion of Pacific islands brings to the traveler's mind a vivid picture of blue sky and sea, a long strip of surf and coral beach, and friendly beckoning cocoa-palms. Hawaii is the northern Oceanic limit of the cocoa-palm, that most widely-known and useful member of an immense plant family. Like the breadfruit, the Hawaiian cocoa-palm, *niu*, does not reach the luxuriant growth that characterizes the more tropical portion of its range. However, it commanded a position of great importance in the economy and lore of the ancient Hawaiian. Extensive groves were maintained by the chiefs at numerous lowland and seaside settlements. A village near Honolulu was called Niu, because of the great grove there. The village, and

nearly all the grove have disappeared, but the name still remains. With the decline of the native population, many of the ancient groves fell into decay. In recent years there have been several commercial plantings; these newer plantations are restoring to Hawaii one of the distinctive features of its Polynesian charm.

The Hawaiians, like the people of all regions where the cocoa-palm thrives, utilized it in many ways—the nuts for food, oil, cups and coir; the leaves for thatch; and the wood for various minor purposes. A delicious brown pudding, *kulolo,* was made of grated cocoanut meat, mixed with grated *taro* or breadfruit. This was wrapped in *ti* leaves and baked. Sometimes the grated meat was mixed with bananas, or was flavored with shrimps. The sweet cool "milk" of the young nuts has been used since the earliest times as a unique and refreshing beverage.

The indigenous palms of Hawaii belong to the genus *Pritchardia* and were called *loulu.* The unripe fruits of several species were used as food, the kernels (*howane*) being esteemed as a delicacy. Fans and hats were plaited from young, unexpanded leaves. The *loulu* palms grew wild in the mountains, and were not generally cultivated, although occasionally a few would be planted near the villages.

Every native settlement, at the time of the coming of the first white men, had its plantations of sugar cane. Its Hawaiian name *ko* is used by other Polynesian tribes. Like all mankind, savage and civilized, the natives were very fond of sugar. They possessed no means of extracting the sugar, save the natural method of chewing the stalk. Sugar cane, like many of the crop plants, is practically seedless, and is propagated exclusively by stem cuttings. The natives cultivated about fifteen varieties, which were distinguished chiefly by the size and markings of the stem, and by the time required for maturity.

The most conspicuous shrub on the valley slopes and in the lower forests of Hawaii is the *ti* or *ki* (*Cordyline terminalis* Kth.). Its erect woody stem, six to fifteen feet high, is simple or sparingly branched, and is terminated by a cluster of large oval leaves. These are one to two feet long, bright green, smooth and papery. The large, tuberous saccharine root was the part used for food. This was dug, cleaned, cut into suitable pieces, and baked like the breadfruit. The cooking enhanced the rich sugary flavor, and made *ti*-root a toothsome delicacy. A mild beer was also fermented from the root, but this did not seem to be general in ancient Hawaii. The strong *ti* spirits of modern times were first made by some Botany Bay convicts, who taught the natives the pernicious craft of distillery.

The representative alcoholic beverage of Polynesia is *awa* (also called *awa-awa* or *kawa-kawa*), or *Piper methysticum.* The ceremonies of preparing and drinking *awa* were complex and ritualistic. The use of *awa* was largely under the control of the nobility; intoxication

in early Hawaii was a prerogative of chieftainship. The *awa* plant is an erect shrub, several feet high; the smooth fleshy stems arise from a thick, spongy rhizome. This underground portion is the *awa* "root" of native trade, which was used for making the beverage. The Hawaiians raised the *awa* plant in small clearings in the lower forest, in much the same manner as *api'i* and *wauke* were grown. They distinguished a number of varieties, mainly by the color of the stem.

One of the most beautiful trees of Hawaiian valley-floors and streamways is the mountain apple, or *ohia ai* (*Jambosa malaccensis* (Linn.) D.C.). It is twenty to thirty feet high, with shining dark green leaves, and a profusion of bright red blossoms scattered along the twigs and branches. These showy flowers give place to equally attractive red "apples." The fruit is about two inches long, obovate, and has a cool, slightly saccharine flavor. This beautiful fruit tree is cosmopolitan in range, and is widely distributed over the Pacific islands. It was introduced by the early Hawaiian, and now forms extensive pure stands in many windward valleys. From the sacred wood of *ohia ai* were hewn many of the ancient idols, and its name is prominent in Polynesian legends.

The Hawaiian huckleberry, *ohelo* (*Vaccinium reticulatum* Smith), is as distinctive of the uplands and mountain ridges as the mountain apple is of the valleys. It was very abundant around the volcano Kilauea, and in the long eras of the *tabu* system was famous as a propitiatory offering to savage Pele, goddess of the crater. The shining red and amber berries have a pleasant sub-acid flavor, and are now used for making jams, pies, etc. In old Hawaii they were used solely as fresh fruit, and their attractive appearance and flavor are often referred to in the ancient songs.

This presentation of the crop plants of ancient Hawaii would be seriously incomplete if some mention were not made of the extensive utilization of sea weeds, *limu*. The Hawaiian villages were almost invariably situated on or near the seashore, and the products of the sea, both animal and vegetable, constituted an important part of the native diet. The Hawaiians were intimately familiar with many species and varieties of marine algæ. Some were collected as flotsam along the beaches; others were secured only at considerable hazard in the deeper waters of the outer reef. Some kinds were highly precinctive, others were plentiful only at certain brief seasons. The algæ were carefully sorted, cleaned, and prepared in various ways as "salads" or relishes.

It is evident that the old-time Hawaiian had a considerable range of crop plants. His crops grew all the year round. He harvested in every month. He knew his plants with microscopic detail, and in his accurate varietal designations recognized the most trivial differences. He was a good farmer, and under his own civilization in times of peace there were few famines and little hunger.

FOSSIL HUNTING IN TEXAS

By EDWARD L. TROXELL, Ph.D.
ANN ARBOR, MICH.

THE romantic side of a collector's experience is often eclipsed by the hardships he has to endure, yet the pleasure resulting from marvelous finds of rare and valuable specimens is only increased by the difficulties attending their discovery.

The *Equus scotti* quarry at Rock Creek,[1] Texas, found by Mr. J. W. Gidley, has furnished many very interesting stories, some valuable scientific data and ten skeletons of a rare prehistoric horse. This species, though having but one toe on each foot is, nevertheless, a direct descendant of the three-toed animal which roamed the western hills millions of years before. It is the last representative of a race whose extinction, in the Western Hemisphere, followed closely the advent of man in the Old World—a period commonly considered at least two hundred thousand years ago. Within historic times the horse, again introduced by the Spaniards, had adapted himself most readily to his original American home.

Mr. Gidley told me recently of the discovery of the hill with its unusual deposit of fossil bones. It was a story of fruitless effort and keen disappointment, ending abruptly in the joys of success. He had searched many times about the arroyo where rapid erosion had exposed the strata. Finally the attempt was given up, but on the way out the party camped at the spring near the head of the creek. Unable to resist the temptation, moved by an overwhelming impulse to hunt once more, Mr. Gidley went out and almost immediately found the portion of bone exposed which lead into this very rare deposit.

Thirteen years later, the Yale Expedition of 1912, under the leadership of Professor R. S. Lull, went to the same quarry to secure if possible another specimen of the extinct horse. Two unsuccessful attempts were followed by the lucky third in which, on the second stroke of his pick, Professor Lull unearthed a bone and shortly discovered the skeleton now mounted in the Yale Museum.

It was with the knowledge of these former successes that I went again in 1914 to the head of Rock Creek in the hope of finding additional material of *Equus scotti*. The first digging in 1899 began at the edge of the sloping hill, but each successive excavation left the bone layer deeper and deeper. The specimen found in 1912 lay buried twelve feet, while those found last year were about fourteen feet beneath the

[1] See Osborn's "The Age of Mammals."

surface. It was necessary, therefore, to use a plow and scraper to facilitate the removal of the thick covering of sand and soil. This could be done only to a depth of ten or eleven feet without endangering the fragile skeletons with the heavy tools. The remaining three feet we moved with our shovels, spading most carefully lest a valuable skull or limb, suddenly appearing, might be seriously damaged.

The first four days were spent stripping the upper layers from a portion of the quarry. On the fifth the spading began, and in just four hours we were rewarded. Four days of preparation and four hours of actual search disclosed the skull of the first specimen; thus, early,

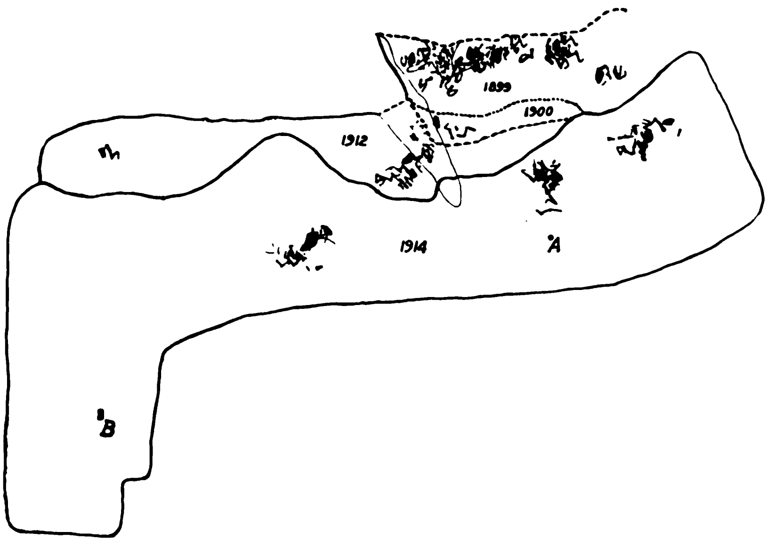

FIG. 1. Gidley's Quarry, showing the successive excavations and the distribution of the various specimens. Over a thousand cubic yards of sand and soil were removed in 1914. *A*. The sixth cervical of a very large camel ***Auchenia hesterna***, found just before the discovery of the second horse near by. *B*. A fragment of the pelvis of the ground sloth ***Mylodon harlani***. These two odd bones show definitely that the deposit belongs to the Earliest Pleistocene.

assuring us of the success of the enterprise. This skeleton, which is now mounted in the Museum of Amherst College, proved to be complete, except for the neck vertebræ, the sacrum and some minor portions, The fossil was treated with the utmost care, for the bones were so very fragile they would have fallen to pieces if picked up prematurely. The matrix of sand was removed with an awl and small brush and before the bones were handled they were hardened with a solution of gum arabic or shellac. Sometimes the larger parts, and those more delicate, were wrapt with strips of cloth dipped in flour paste before they were turned over. In every case they were so treated before shipping and some were even bandaged with plaster before packing in boxes of straw

or hay. About a week was consumed in taking up the parts. In the meantime the search, which was continued through the adjoining area of fifty square yards to the south, revealed not a single bone except those immediately about the skeleton already described.

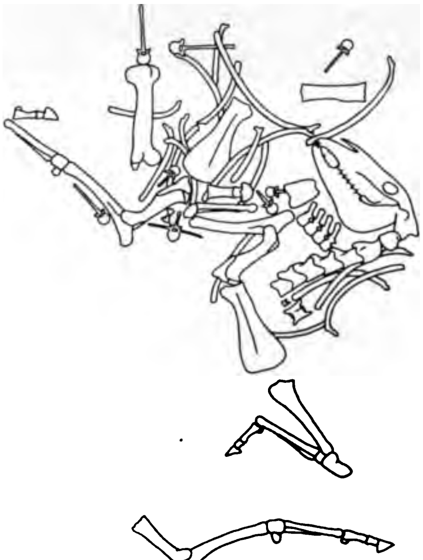

FIG. 2. The second specimen of the horse *Equus scotti*. Note the dismantled and jack-strawed character of this young skeleton.

Just two weeks after the first discovery, the scraper uncovered the neck bone of an animal much larger than a horse. It proved to be the cervical of a very large camel. Its very unusual position, about three feet above the main bone layer, accounts for the ruthless treatment,

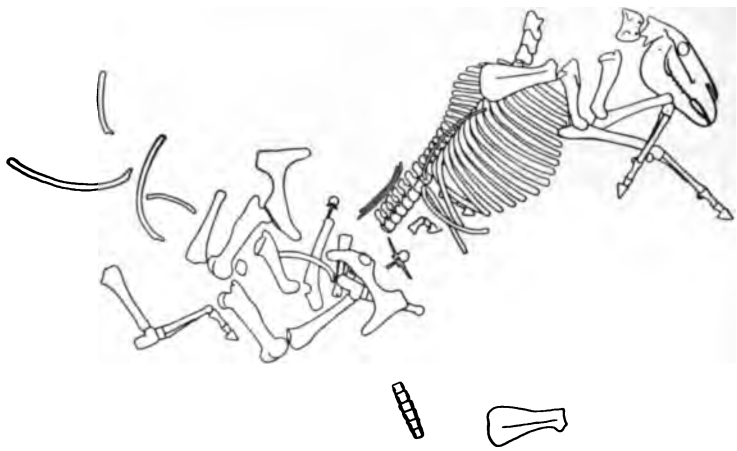

FIG. 3. The third specimen of *Equus scotti*, the last and most perfect of those taken out of the quarry; a mature individual. Now at the Victoria Memorial Museum, Ottawa, Canada.

FIG. 4. A view of the trench from the bottom of which came the third specimen. The left bank had to be removed entirely.

its discovery with the scraper. This strange bone made such an impression on my mind that, together with the physical exhaustion from the work and a hard bed of straw, my sleep was very much disturbed. I could think of nothing but bones, of horse skeletons broken up and all dismembered. The dream seemed so real that I related it the next morning to the men, indicating the spot where the bones seemed to lie. I offered them each two days' extra pay if they found the skeleton, and proceeded to my work on an elephant's skull a mile away. About nine-thirty one of the men came over and said: "We've sure enough found it." I was not in the least surprised: although it was lying within three feet of, and probably on the identical spot I had earlier pointed out, and strangely enough the bones, while individually in excellent preservation, were all disarticulated, a character peculiar to an immature individual. The skeleton proved to be that of a young stallion, as indicated by the large canine teeth, the so-called "tusks."

I have seldom seen fossil bone in a more excellent state of preservation. It was a smooth pale yellow turning white on exposure to the air as the evaporating moisture deposited its mineral content on the surface. The bones had been well protected from the agents of weath-

ering beneath the thick blanket of sand; while, roots, usually so destructive to fossils, had only slightly etched the surface of a few parts. This skeleton was complete except for a part of the back bone, the pelvis, a few ribs and one hind limb.

Shortly after finding the second horse the scraper disclosed another unusual bone, which, like the camel cervical, was about three feet above the main deposit. This large block was a fragment of the pelvis of the ground sloth, *Mylodon.*

Continuing the hunt with our shovels, in the fifth week we were fortunate enough to find a third horse. At first only the hind quarters were visible, as the bones lay in the bottom of a narrow trench. Since

FIG. 5. The hind quarters of the third specimen, which can be identified in the drawing, Fig. 3. These bones lying in the bottom of the trench were found after having removed fourteen feet of sand and clay.

the end of the back bone was protruding from beneath fourteen feet of sand, it was necessary to tear away completely the small outlying hill forming one wall of the trench in order to secure the front quarters. This third horse is undoubtedly the most perfect of all the ten specimens discovered in the quarry. It lacks only the sacrum and three parts of the neck. In marked contrast to the second specimen, a young animal, the third shows how much more firmly, in maturity, the bones are knit together and kept in their proper positions by the cartilages. The fore quarters of the last specimen were practically

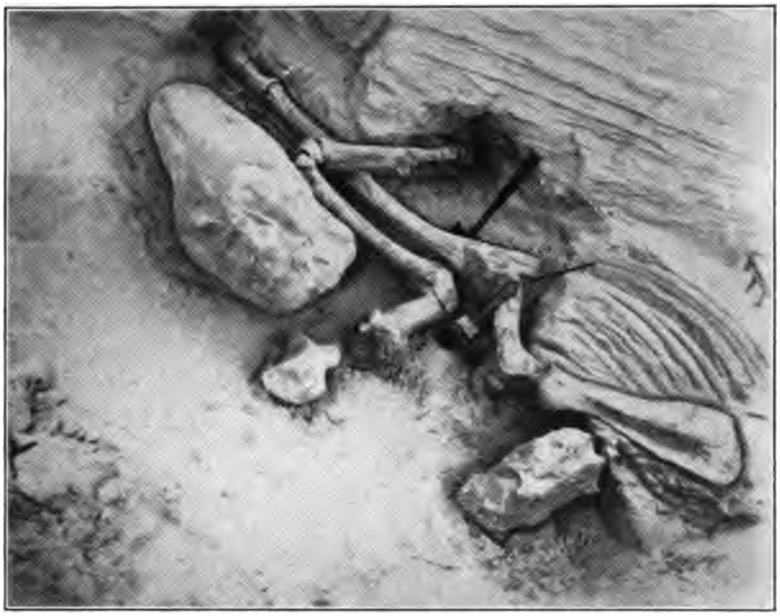

FIG. 6. The fore quarters of the third specimen, after the removal of the outlying hill. (See Fig. 8.)

intact. The position of the front limbs is most impressive as one imagines the poor victim in the sand struggling his last, then quiet.

No other complete skeletons of fossil *Equus* have ever been found outside the Gidley Quarry. The nearest approach is from the asphalt deposits of Rancho La Brea, California, "where a number of good skulls have been obtained with much material consisting of loose teeth and elements representing all parts of the skeleton" (Merriam). Only two other species are known even by single skulls.

A study of the geology of the quarry furnished some interesting problems. The question is frequently asked: "How did the horses get there?" Of course it is impossible to give a positive answer, but very probably they were mired in the sands of an ancient stream bed or caught in its waters and drowned. The close association of the skeletons makes it appear that the animals were swept together in a whirlpool. Miring in quick sand occurs so commonly to-day that it offers an explanation easily understood and readily accepted. The fine sand found in the quarry even when dry is most difficult for a horse to traverse and if wet would make a veritable trap. A peculiar fact, noted in connection with the three horses found in 1914 and the specimen of 1912 (the only ones with which I am personally familiar), is that the heads are all pointed toward the northeast. Professor Williston has described a herd of fossil peccaries all headed one way and he

presumes that they were overcome while fleeing before a dust or snow storm. In the present case it is more probable that the horses were moved by the stream. The body, distended with gases, would float more readily than the head; the latter acting as an anchor would drag behind in the shallow water and on coming to rest would point in a general direction up stream. This conclusion is supported by observed ripple marks which in a north-south section showed that the current was coming from a northerly direction.

It is certain that the carcasses lay, before burial, long enough for the flesh to decay. We find the skeletons dismembered and the bones

FIG. 7. The face of the twelve-foot bluff left by the Yale expedition of 1912, now entirely removed.

scattered; some parts are entirely lacking and frequently the members of separate individuals are associated together. The scattering of the parts may have been accomplished by carnivorous animals tearing at the flesh; a portion of one rib showed markings like those of a gnawed bone.

The more violent current which began the process of burial gave way to one more and more gentle, until when three feet of sand had been deposited the water was so calm as to allow a half inch of clay to settle down from the material in suspension. It was at this level that the camel and sloth bones came to rest. They were then buried by a gentle action of the stream depositing evenly bedded layers of sand to a depth of six feet, above this was a great quantity of clay. At one time

the skeletons were probably buried to a depth of fifty feet, when the whole area was built up to the level of the High Plains.

Recent stream action has cut out the canyons and arroyos, laying bare the underlying strata. The present drainage is toward the east; when the bones were deposited it was toward the south or southwest, but at a time between the periods of these two, a third system carried its waters off toward the north. On the diagram, Fig. 1, can be seen the refilled remnant of a "V"-shaped channel crossing the quarry. Where it cut the fossil bed the bones were shifted, waterworn and redeposited at a lower level.

The geological age of the formation was assumed to be Early Pleistocene. The finding of the two unusual bones, one the sixth cervical

FIG. 8. The process of removal of the hill overlying the third specimen. The soft sand was dug from beneath, allowing huge blocks to fall of their own weight.

of *Auchenia hesterna,* a large camel, the other a portion of the pelvis of the ground sloth *Mylodon harlani,* proves beyond doubt that the fossils not only belong to that period, but to the true "Equus Beds." In addition to these single bones, actually excavated, there were also found, farther up the hill, some pieces of ivory from the broken tusk of an elephant. These odd fragments are practically valueless for exhibition purposes, but from a scientific standpoint are really of very great interest since they determine the period in which the horses lived.

A rough estimate of the summer's work shows that over a thousand cubic yards of earth were removed, weighing approximately fifteen hundred tons. This covered an area of over three hundred square yards. The work occupied a period of about seven weeks; during that time a team was used but eleven days and the equivalent of one assistant for forty-eight.

The region about the head of Rock Creek was once the home of great hordes of prehistoric animals, which we now know only by their abundant fossil remains. In this small area as many as fifteen dif-

FIG. 9. A distant view of the Quarry, the wall left standing and the white material carried out in the process of excavation.

ferent species have been found represented to-day by the turtle, peccary, horse, ass, sheep (?), dog, sloth, elephant, camel and an extinct animal *Glyptodon* whose nearest living relative is the armadillo. Most of these species have been discussed in recent issues of the *American Journal of Science* and new types are furnished by a dog, an ass and a ruminant.

THE LIBRARY AND OTHER BUILDINGS OF COLUMBIA UNIVERSITY AS SEEN FROM SOUTH FIELD

THE PROGRESS OF SCIENCE

THE CONVOCATION WEEK MEETING AND COLUMBIA UNIVERSITY

It was not until nearly forty years after its foundation that the American Association for the Advancement of Science first met in New York City. The second meeting was held in July of 1900, with an attendance of about 700 scientific men, the membership of the association then numbering about 1,700. In 1906 the association held its third meeting in New York City, convocation week having in the meanwhile been established at the end of the year for the meeting of the association and its affiliated national societies. At this meeting the attendance of scientific men was about 2,000 and the membership of the association had increased to about 5,000. Now, when the association, after an interval of ten years, meets for the fourth time in New York City, the membership has increased to about 11,000 and the number of affiliated societies in proportion, so that, including the sections of the association, about fifty-five national scientific organizations will meet simultaneously during the week beginning on December 26.

The meetings of the association, of its sections and of the affiliated societies are held in the different institutions of the city, but Columbia University has been the headquarters at all the meetings. The growth of the university has been about in proportion to the growth of the association. In 1900 the university had recently removed from its site on Madison Avenue and 49th Street to its present location at Morningside Heights. At that time the students numbered 2,812. The officers now number 1,188 and the students 18,176. It should, however, be noted that this large number of students includes over 8,000 summer-school students and over 5,000 students under extension teaching, who do not do a full year's academic work. Since 1900 the several corporations included in the university have received gifts amounting to about $25,000,000. The grounds have been so much enlarged during this period and so many new buildings have been erected, that scientific men who have not visited the university since 1900 or even since the meeting in 1906 will find great changes.

There are here reproduced views of some of the buildings of the university, though the whole institution is of such magnitude that it is difficult to give an adequate impression. The university library, the gift of the late Seth Low, president of the university from 1889 to 1891, is the central feature of the buildings comprising the northern group, which together form a large quadrangle. It is of Indiana limestone, while the other buildings, in conformity with the general design, are constructed of fire-burned brick and limestone, set on a base of granite. The view showing the library is taken from South Field, which contains three large dormitories, the college building and the School of Journalism. A gift of $600,000 has just been announced for a building for the School of Commerce, to be erected opposite the School of Journalism and corresponding in position to the School of Law. Earl Hall, the home of the religious and social interests of the students, will be the registration headquarters of the association.

The buildings of Barnard College and Teachers College, which are independent corporations, have been added to with the same rapidity as the build-

ON THE COLUMBIA UNIVERSITY CAMPUS

ings of the university. The growth of Teachers College, whose students number over 2,000, is especially notable. The section of education of the association, which was established at the New York meeting ten years ago, will hold its sessions there. The beautiful new buildings of the Union Theological Seminary, which is educationally affiliated with the university, are adjacent and will be the headquarters of the American Philosophical Association. The other educational and scientific institutions of New York City have grown at the same rate as Columbia University. New York University has been established in a beautiful site, overlooking the Harlem river. One of the notable events of the meeting of the association ten years ago was the visit to the City College, which had just moved into its magnificent new buildings. The American Museum of Natural History has notably enlarged both its buildings and its collections. The Botanical Garden and the Zoological Park have become institutions almost unrivalled.

PROGRAM OF THE MEETINGS

PERHAPS the best idea of the magnitude of the meeting of the American Association and its affiliated societies can be given by abridging from the preliminary program some account of the sessions as grouped under the sections and the special societies related to them. This can by the nature of things be little more than a list of societies and of names. It will, however, give some idea not only of the present convocation week meeting but also of the organization of science in this country.

At the opening general session on the evening of December 26 at the American Museum of Natural History, Dr. Charles R. Van Hise, president of the University of Wisconsin, will preside, and Dr. W. W. Campbell, director of the Lick Observatory, will give the address of the retiring president on "The Nebulæ." After the address there will be a reception to the members of the Association and affiliated societies by the president and the trustees of the museum.

EARL HALL. Registration Headquarters of the American Association

Section A, Mathematics and Astronomy, will hold a general session, which will include the address of Professor Armin O. Leuschner, of the University of California, on the "Derivation of Orbits." *The American Mathematical Society,* the *Mathematical Association of America,* and the *American Astronomical Society* will meet in affiliation with the section.

Section B, Physics, will listen to the address of Professor Percival E. Lewis, of the University of California, on "Recent Progress in Spectroscopy." Papers on physics will be on the program of the *American Physical Society,* but there will be a general-interest session held jointly with Section C and the *American Chemical Society.* The *Optical Society of America* will meet in affiliation with the section.

Section C, Chemistry, will have as its vice-presidential address, "Asymmetric Syntheses and their Bearing upon the Doctrine of Vitalism," by Professor William McPherson, of the Ohio State University. Sections B and C, in conjunction with the *American Chemical*

Society and the *American Physical Society,* will hold joint sessions on "The Structure of Matter." On Thursday evening, at the American Museum of Natural History, Professor A. A. Noyes, of the Massachusetts Institute of Technology, will give one of the lectures complimentary to the citizens of the city on "Nitrogen and Preparedness." This lecture will be followed by a reception and a chemical exhibit.

Section D, Engineering, will hold a session in the Engineering Societies Building, on the invitation of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. At this meeting, Dr. Bion J. Arnold will give the address of the retiring chairman, and there will be addresses by representatives of the engineering societies, followed by a reception to engineers and those working in sciences related to engineering. Section D will hold a joint session in the assembly hall of the *Automobile Club of America,* with the *National Highways Association,* the *Automobile Club of America,* and the *National Automobile Chamber of Commerce.* There will also be joint sessions with the *Society for the Promotion of Engineering Education.*

Section E, Geology and Geography, will have a special program by State geologists on the geology of their respective states. *The Association of American Geographers* will hold its meetings following those of the geologists. The address of the president, Professor Mark Jefferson, of the Michigan State Normal College, will be on "The Geographic Provinces of the United States."

Section F, Zoology, will hold its meetings with the *American Society of Zoologists* and the *American Society of Naturalists.* Professor Vernon L. Kellogg, of Stanford University, will give the address of the retiring chairman. A dinner in honor of Professor E. B. Wilson, a past-president of the association, will be given at the Hotel Manhattan by his former students and colleagues. *The Entomological Society of America* will have an address by the retiring president, Professor T. D. A. Cockerell, on "Fossil Insects." *The American Association of Economic Entomologists* will listen to an address by the president, Dr. C. Gordon Hewitt, of the Dominion Experimental Farm at Ottawa.

Section G, Botany, will hold a general-interest session at which the address of Professor William A. Setchell, of the University of California, on "The Geographic Distribution of the Marine Algæ," will be given. This will be followed by a symposium on the relations of chemistry to botany, a joint session with the *American Botanical Society,* the *American Phytopathological Society,* and the *Ecological Society of America.* A dinner for botanists will be given at the Hotel McAlpin, at which the address of Professor John M. Coulter, the retiring president of the *Botanical Society of America,* on "Botany as a National Asset," will be given.

The American Society of Naturalists will hold a symposium on "Biology and National Existence," with papers by Stewart Paton, W. J. Spillman, Vernon L. Kellogg, Jacques Loeb, and Edwin G. Conklin. After the dinner at the Hotel Manhattan Professor Raymond Pearl, of the Maine Experiment Station, will give the presidential address. *The New York Zoological Society* will entertain at the New York Aquarium the members of the Society of Naturalists and related societies on the evening of December 27. *The American Genetic Association* will have an important program.

Section H, Anthropology and Psychology, will refer special papers to the *American Anthropological Association* and the *American Psychological Association.* The address of the retiring

Chairman, Professor Lillien J. Martin, of Stanford University, will be on "Personality as revealed by the Content of Images." *The American Anthropological Association*, under the presidency of Dr. F. W. Hodge, of the Bureau of American Ethnology, will meet at the American Museum of Natural History. In affiliation with it will meet the *American Folk Lore Society*, the address of whose president, Dr. Robert H. Lowie, of the American Museum of Natural History, will be on "Oral Tradition and History." *The American Psychological Association* celebrates the twenty-fifth anniversary of its foundation with historical papers by G. Stanley Hall, J. McKeen Cattell, Joseph Jastrow, and John Dewey. The address of the president, Professor Raymond Dodge, of Wesleyan University, on "The Laws of Relative Fatigue," will be followed by a smoker. The annual dinner will be at the Hotel Marseilles. The association will hold a joint session with the section of education on Friday. *The American Philosophical Association* will meet at the Union Theological Seminary, adjacent to Columbia University.

Section I, Social and Economic Science, will listen to an address on "Scientific Efficiency and Industrial Museums, our Safeguards in Peace and War," by Dr. George F. Kunz, of New York. The programs of the section will consider the metric system, the national thrift movement, and the effect of peace on our economic conditions. There will be a meeting treating "Insurance" in the Metropolitan Auditorium, Madison Square.

Section K, Physiology and Experimental Medicine, will meet at the American Museum of Natural History on Friday afternoon. Professor Frederic P. Gay, of the University of California, will make an address on "Specialization and Research in the Medical Sciences" and there will be a symposium on "Cancer and its Control," taken part in by Gary N. Calkins, Leo Loeb, J. C. Bloodgood, James Ewing and E. C. Lakeman. This will be a joint meeting with the *American Society of Bacteriologists*. The Federation of American Societies for Experimental Biology, consisting of the *American Physiological Society*, the *American Society of Biological Chemists*, the *American Society for Pharmacology and Experimental Therapeutics*, and the *American Society for Experimental Pathology*, will meet at the Cornell Medical College. There will be dinners on Thursday and Friday evenings. The *American Association of Anatomists* will hold its meetings in the anatomical laboratories of three medical schools of the city, under the presidency of Professor Henry H. Donaldson, of the Wistar Institute. Dr. Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research, will give one of the public lectures before the association on "Infantile Paralysis and the Public Health."

Section L, Education, will have, as the vice-presidential address, "Some Obstacles to Educational Progress," by Professor Ellwood P. Cubberley, of Stanford University. The section will have discussions on educational tests and measurements, research problems, and administrative problems. *The American Nature Study Society* and the *School Garden Association of America* are among the societies meeting with the association. *The Society of the Sigma Xi* will hold its annual convention at Columbia University on the afternoon of Wednesday, with its dinner in the evening, at which there will be an address by the president, Dr. Charles S. Howe, president of the Case School of Applied Science. *The American Association of University Professors* will meet at Columbia University on Friday and Saturday, with a dinner at the Hotel Astor on Friday evening.

Section M, Agriculture, will meet Wednesday. The address of the retir-

ing vice-president, Dean Eugene Davenport, of the University of Illinois, will be on "The Outlook for Agricultural Science." This address will be followed by a symposium on the same subject, which will be taken part in by H. J. Wheeler, J. C. Lipman, G. F. Warren, and B. Youngblood. *The Society for Horticultural Science,* and *The Association of Official Seed Analysts* will meet at Columbia University in affiliation with the section

SCIENTIFIC ITEMS

WE record with regret the death of Dr. Hugo Münsterberg, the distinguished German psychologist, professor at Harvard University since 1892; of Sir Hiram Stevens Maxim, the well known inventor; of Henrik Mohn, the Norwegian meteorologist; and of Dr. Oskar Backlund, the eminent director of the Imperial Observatory at Pulkova, Russia.

A BUST of John Muir was unveiled at the University of Wisconsin on the evening of December 6. The bust was presented by Mr. T. E. Brittinham to the university where Muir was a student for four years. Dean E. A. Birge presided, and addresses were made by Regent Charles H. Villas and President Charles R. Van Hise.

THE president and council of the Royal Society have made the following awards: A Royal Medal to Dr. John Scott Haldane, F.R.S., for his services to chemical physiology, more especially in reference to the chemical changes of respiration. A Royal Medal to Professor Hector Munro Macdonald, F.R.S., for his contributions to mathematical physics. The Copley Medal to Sir James Dewar, F.R.S., for his investigations in physical chemistry, and more especially his researches on the liquefaction of gases. The Rumford Medal to Professor William Henry Bragg, F.R.S., for his researches in X-ray radiation. The Davy Medal to M. le Prof. Henri Louis le Chatelier, For.-Mem.R.S., for his researches in chemistry. The Darwin Medal to Professor Yves Delage, for his researches in zoology and botany. The Sylvester Medal to M. Jean Gaston Darboux, For.Mem.-R.S., for his contributions to mathematical science. The Hughes Medal to Professor Elihu Thomson for his researches in experimental electricity.

Vol. 4, No. 2 FEBRUARY, 1917

THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENCE PRESS
LANCASTER, PA. GARRISON, N. Y.
NEW YORK: SUB-STATION 84
SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION, $3.00

THE SCIENTIFIC MONTHLY

FEBRUARY, 1917

THE MIRIAMITES

By HUBERT LYMAN CLARK

MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE, MASS.

ALTHOUGH the name sounds Biblical, the Miriamites are not one of the lost tribes of Israel. There is nothing Hebraic about either their faces or their language. Yet there is some justification for calling them a lost tribe, for they dwell far removed from their racial stock on a few small islands in the Coral Sea. Living as they do under the protection of the Queensland government, yet seldom in touch with white men, they have retained a child-like simplicity and charm which makes them unusually interesting to those who are fortunate enough to visit the islands where they dwell. The shallow water of Torres Strait abounds in islands, many of which are, or have been, inhabited, but on only those lying most to the northeast have the Miriamites found a home.

These islands are known to their own people as Erub, Mer, Dauer and Weier. On English charts, however, Erub is called Darnley Island, while the other three are grouped together as the Murray Islands. Erub is the largest, having a shore line of perhaps eight miles, but Mer is the highest, the "top of the island" being 750 feet above the sea. The Murray Islands lie only four miles within the Great Barrier Reef and from the summit of Mer the long swell of the Pacific beaten into snow-white breakers upon it is easily seen. Dauer and Weier are little more than a mile south of Mer, but Erub lies twenty-five miles to the north. All through the region, reefs and shoals abound and upon some of these the ceaseless movement of the sea has built low islands, a few of which are more or less covered with vegetation, including, of course, the ubiquitous coconut palm. A few miles north of Erub lies one of the largest of these coconut-islands, Uga (Stephen's Island of the charts), noted for its fertile soil. Uga shares with Erub and Mer the honor of being the home of the Miriamites.

Centuries ago, long before Torres sailed through the strait which bears his name, Australia was the possession of nomadic tribes of a lowly black race, remnants of which are now the wards of their Anglo-

LANDING ON ERUB.

Saxon conquerors. New Guinea was peopled by a primitive Melanesian stock, of relatively low intelligence. Northwestward in the East Indies was a higher, stronger, more pugnacious race. Slowly but steadily, pressure from the Malay archipelago initiated one of those migratory movements for which the region is renowned, and the simple people of northern and eastern New Guinea were forced to move. Many turned westward into that part of the island now under Dutch control, where they were isolated by the encroachments of the higher race which soon dominated eastern Papua. Others, following lines of least resistance, passed southward to the islands which abound in Torres Strait. The eastern Papuans, however, were not content with driving their less pugnacious brethren before them into the islands. They followed them there, conquered them, intermarried with them, and thus gave rise to the bright, intelligent natives of Badu, Moa and the other islands lying north of Cape York But for some unknown reason, the few small islands at the northern end of the Great Barrier Reef, far to the eastward of Cape York, were never reached by the conquerors and there a fragment of the defeated race, the Miriamites of the present time, have found a sanctuary to this day.

Indefinitely long ago, volcanic outbursts, accompanied by great changes of shore-line along the Queensland coast, disturbed the region now covered by the Gulf of Papua, and New Guinea was finally separated from the Australian mainland. Volcanic peaks and cones, scat-

tered here and there, still remain as traces of the old land-bridge. Of these, because of their present isolation and beautiful scenery, the most interesting are the four above mentioned and which still show clearly their volcanic origin. The soil is very fertile and, except on almost vertical slopes, is thickly clothed with vegetation. The torrential downpour of the rainy season has greatly softened all rugged outlines and surrounded each island with a narrow strip of level land on which the coconuts flourish. The rains too give rise to streams which have cut deep and picturesque ravines and gorges on their way to the sea. But during the long rainless season, these stream-beds become quite dry and for a water-supply, the people have to depend on a few deeply sunken cisterns and on storage tanks.

The Miriamites are so similar to negroes in their general appearance, a close examination is neecssary to show that they are not really of negroid stock at all. The very dark skin, broad nose and woolly hair are characters obviously like those of Africans, but the shape of the skull and the thinner lips are evident differences. Customs and language yield satisfactory proof that the ancestry was Melanesian and not even remotely traceable to Africa. The language is particularly interesting and is of great importance in attempting to follow the history of the islanders. The speech is known as Mer or Miriam and hence the people, though usually called Murray Islanders, should be designated as

THE CHURCH AND PARSONAGE AT ERUB.

GOING INTO SCHOOL, ERUB.

Merites or Miriamites. The former name, however, implies birth or residence on Mer and so, like "Murray Islanders," is objectionable, since half the Miriamites live on Erub and Uga. Nobody knows how large a company first found shelter on the islands, but, at the present day, there are between eight and nine hundred, all told. Of these about half reside on Mer, more than three hundred on Erub and the remainder on Uga. Dauer no longer boasts any permanent residents, but gardens are still maintained there by natives living on Mer. The improved social conditions on the larger island, accompanying the development of church and school, caused this short but complete migration. A similar movement is now in progress further north, where the people of Uga are passing over to the socially more attractive, but agriculturally less desirable, Erub. In this case, however, Uga is so fertile and lies so far from Erub, it is not likely to ever wholly lack inhabitants as Dauer does to-day. Vital statistics kept on Mer for the past twenty years show that the Miriamites are not dying out, but are rather more than holding their own. The abundance of children on both Erub and Mer is further confirmation of the fact.

Intellectually the Miriamites do not rank high. Their language is curiously complex in certain details, particularly in prefixes and suffixes to verbs to express slight differences of sense or of mood and tense. Yet in vocabulary there is a striking absence of many common words and even numerals above two were lacking in the original tongue, though now transferred more or less bodily from English. Thus in the

translation of the Gospels, used in the churches, two is *neis,* but three is *thri;* four is *neis a neis* or *foa;* five is *faif;* six, *sikes,* etc. Apparently for practical purposes, counting "one, two, few, many," answered all requirements. Although the schools are conducted in English, and have been for twenty-five years, few Miriamites speak the language readily enough to maintain conversation in it. Most of the dealings with foreigners are transacted in a curious "pidgin English" which knows neither case nor gender, but which is remarkably effective for conveying ideas.

About forty years ago, the London Missionary Society began work among the Torres Strait islanders and Erub and Mer were two of the first stations occupied. Schools were of course a very vital part of the work, so that for more than a generation the Miriamites have had an elementary English education. The children take to school work well, but sooner or later seem to reach an intellectual limit beyond which they can not progress. It is a notable fact that not one of the pupils has shown sufficient ability and inclination to become a teacher of his own people. At the present time, the Miriamites are all nominal Christians, and their island homes are no longer mission stations. There is a church on each island maintained by the London Missionary Society. On Erub, the pastor is an Ellice Islander, while on Mer a Samoan looks after the spiritual interests of the people. These men are intellectually far superior to their parishioners, but they live the same simple, easy-going life and hence do not seem so foreign as white men would.

A Group of School Children, Erub.

The Queensland government maintains a school on Erub and another on Mer. These schools are in session from forty to forty-five weeks each year and are taught by white men who are also the general representatives of the government. Mr. Williams, the teacher at Erub, is a Welshman who has been a lay-missionary in New Guinea, while Mr. Bruce, the teacher at Mer, is a Scotchman who has resided there twenty-three years, and so is now a father to the whole island. It is remarkable and most fortunate that it is possible to procure for these isolated schools men of such intellectual caliber and rugged Christian character. Situated as they are, their responsibilities are really very great, for the Miriamites are very child-like, easily led and easily misled. To protect them, the Queensland government has made their island homes reservations upon which no whites or other foreigners may take up their residence. Nor may they even remain on shore for so much as over night without official permission. The sale or giving of liquor to the people is, of course, prohibited, and there is little violation of this law. White men are rare visitors to these out-of-the-way islands, the principal foreigners being Japanese employed on pearl-fishing boats.

Thanks to the paternal care of Queensland, the Miriamites are rarely in want. Men, women and children look well-fed and healthy. They are cleanly in their habits, and skin diseases and other repulsive evidences of unsanitary living are conspicuous by their absence. The men are well-built and often fine appearing; a few are positively handsome, with bright, intelligent faces. The women, too, especially the younger ones, are attractive and often really good-looking. Both sexes work in the gardens and both join in the fishing, but the women seem to be more persistently industrious and are less given to playing games. Fifteen or twenty years ago one of the chief amusements of the men was making and spinning tops. These were of simple, but unusual, construction. A stone of volcanic origin, evidently consolidated ash, was split in two and the half was ground into as perfect a lens shape as possible, flat above and evenly convex below. A hole was bored through the center and in this was inserted a hard-wood stick. The flat upper surface of the top was usually adorned with one or more colored circles. These stone tops were from six to nine inches in diameter and weighed several pounds. When skilfully handled, a perfect one would spin for twenty-five minutes or more! The top-spinning craze became so absorbing that it was finally necessary to put certain restraints upon it. With characteristic childishness, the men turned to other amusements and the fad rapidly died out. At the present time there is no top-spinning on Mer, tops are no longer made and it is very difficult to procure a good specimen of the toy. Just now a kind of ball game, in which a small ball is batted about in the air by the hands, is very popular, a half-dozen or more men playing on each side. Sometimes the younger women join in this game and then the hilarity is considerably increased.

As in many a better-known community, one of the diversions of the men of Mer is politics. The island is divided into four districts, each of which is entitled to a member of the Council, which under the guidance of Mr. Bruce governs local affairs and looks after the maintenance of order. Elections are held in December, biennially. It is regrettable to find that even in such a small and simple community the difficulty of getting the office to seek the man rather than the ambitious man the office occurs, as in our own land, and unfit men are occasionally chosen. At the election in 1912, a man called "Benny" was elected one of the four councilors. About two months later, it was reported that there had been a disorderly disturbance in Benny's village and the councilor, instead of attempting, in accordance with the dignity of his office, to maintain order, had actually been mixed-up in the affair. He was arrested and tried. Being found guilty, he was reprimanded and released on his good behavior. But alas for human frailty, the very next day he became an active participant in another fight. This was too much for the orderly Miriamites. Benny was deposed from office and a special election was immediately held for the choice of his successor.

Fishing and gardening are the chief serious occupations of the men. Some of them find employment on pearling boats, where the use of a pump to supply air to the diver necessitates a large amount of cheap, unskilled labor. Both Erub and Mer own small schooners (called cutters), which are manned by residents of the owning island. These vessels serve not only as a means of communication with the outside world, but are also employed in gathering beche-de-mer, for which a ready market is always to be found at Thursday Island. During the rainy season great schools of fish visit the reef-flats of Erub and Mer. To capture them, the people have built stone walls extending out some distance from high-water mark and connected across the ends by similar walls parallel to the shore. At low water these fish-pounds are more or less completely drained, but at high tide they are filled and the outer walls, at least, are covered by several feet of water. (The rise of spring tides may exceed ten feet.) The fish come in with the rising tide, following it nearly to high-water mark. When it ebbs, they retire slowly, keeping near the bottom and thus they become prisoners within the pounds. This wholesale capture of fish is one of the most characteristic features of Miriamite life and is the most notable occupation of the rainy season. In the dry season, fish are captured in small numbers by spearing and now-a-days the hook and line method is not disdained. Marine turtles appear more or less regularly all the year round and from the Miriamite point of view are among the most useful animals of the sea. Both the eggs and the meat are highly regarded and the capture of a turtle or the finding of a freshly-laid batch of eggs is a cause for great rejoicing.

Domestic animals are in little vogue on either Erub or Mer. Now and then a dog, pitifully thin and dwarfed from long-enforced vegetarian diet, is a treasured possession of some family. A few cats are to be seen and as they no doubt capture mice and birds and make a comfortable living at it; they look far more healthy than the dogs. At various times cattle, goats and pigs have been tried on Mer, but all of these animals have so persistently sought the gardens for their foraging grounds that they proved to be intolerable nuisances and it was necessary to exterminate them. Chickens are kept in some numbers and both they and their eggs are greatly prized.

IN GALA DRESS.

The gardens on Mer, to which reference has already been made, cover a large part of the northern half of the island. The whole interior of Mer is raised two hundred feet or more and a large part of this plateau is very fertile. There are no dwellings there, all of the people living on the flat strip of land which borders the northern and western sides of the island. As the journey to the gardens is rather long and involves a very steep climb, it is customary to go up for the day, taking along some food and water for refreshment. Sometimes a considerable party go together and make a real picnic of the affair, the work on such occasions occupying a secondary place in the day's program. If food is plentiful, the party join in a "kaikai" or, in American college slang, an "eat." Should there be many present and provisions abundant, the occasion becomes an "aule kaikai" or great feast, literally a "big man eat."

The two staple crops of the islands upon which the Miriamites really depend and in the cultivation of which they constantly labor, are yams and bananas. There are several varieties of yams grown, the commonest being much like an American sweet potato but with very pale yellow flesh. The most remarkable yam is a large, white one, the vines of which are such climbers that poles are used to lead them up into trees, where they have abundant opportunity to spread. It is a common thing to find a tree, surrounded, at a distance of twelve to fifteen feet from the trunk, by a circle of ten or a dozen yam-hills from each of which a long, slender bamboo pole reaches into the branches. Yams are planted in the early part of the rainy season and are dug as occasion demands after the dry season is well under way. Bananas are cultivated in even greater variety than yams, no fewer than twenty-two kinds being grown on Mer. Some of these are really plantains and are used only after being cooked. Some are delicious little fruits only two to four inches long and an inch thick, with thin skins and firm, sweet flesh. Others are big, pulpy bananas, five to seven inches long and two to three inches in diameter. Owing to the abundance of very large yellow locusts, which would do great damage to the ripening fruit, it is customary on Mer, when the bananas are full-grown, to wrap the bunch in "trash" (*i. e.,* dried banana leaves), while it still hangs on the tree. There it is allowed to remain until wanted. The wrapping is done very neatly and the nicely tied-up bunches give an odd appearance to the gardens. Aside from yams and bananas, little is cultivated by the Miriamites. Papaws are grown in some numbers and the trees bear very well. Now and then a large pepper plant with bright red fruits is seen in the gardens. Coconuts grow in great profusion on all the lower parts of the island, but in many places are so close together their bearing powers are greatly decreased. The men can not be induced to thin them out, having a very strong, if not actually superstitious, antipathy to cutting down or injuring a coconut tree. The palm provides not only refreshing drink, while the fruit is green, and food when it is ripe, but a large proportion of the materials used in buildings and their furnishings. There are extensive groves of bamboo on Mer, which are of great value, furnishing as they do the framework for all ordinary buildings and material for innumerable useful articles.

Architecture at Mer is still very simple. Most of the houses are rectangular and contain only one or two rooms. The floor is commonly mother-earth, but in the better class of houses is of bamboo and is well raised above the ground. The poorest houses have only a single doorway and a small, square window opening, but the best have several doors, windows with openings protected by mats, and more or less extensive porches. The bamboo framework of these houses is covered with either a thick layer of coarse grass, put on vertically, each tier overlapping the

THE COURT HOUSE AT MER.

one below, or coconut leaves interwoven and more or less matted together. The roofs are grass thatch. The ugly but convenient and serviceable corrugated iron house, so predominant a feature of tropical Australian towns, has reached Mer, but there are as yet only two examples of it. On the hillside back of Mr. Bruce's home is the school house, a commodious frame building, while only a few steps distant is the church, built in part of wood, but largely of coral rock. The church on Erub is wholly of stone, neatly whitewashed and very picturesque. The most imposing building on Mer is the courthouse. This is situated on the hillside, fifty feet or more above the village on the northwestern side of the island and has a fine outlook over the sea. The walls are entirely of stone, the floor is concrete and the roof is corrugated iron. A veranda surrounds it on all sides. There is a doorway at each end and on each side, and there are a dozen window openings, but doors and windows are wholly lacking. The interior consists of a single room about forty feet long by twenty wide, with a ceiling neatly made of split bamboo rods. This courthouse was cheerfully yielded to us for our laboratory and home during our stay and it served our purpose admirably. The jail near by, built of bamboo, cocoanut leaves and grass, was also placed at our disposal and was useful as a storehouse. Not many Anglo-Saxon communities could give up courthouse and jail for six weeks with no appreciable effect on the social order!

The Miriamites are exponents of the simple life. During the dry season most functions, even of a domestic sort, take place out of doors.

Soon after daylight the daily routine begins. Dressing is not a source of trouble or anxiety. For the smaller children, those under four or five years, it consists of rubbing the eyes, yawning and occasionally a dip in the sea. The older boys and men wear a "lava-lava," the universal costume of South Sea islanders. This is a strip of bright red or blue cotton, usually with white figures, about six feet long by two and a half wide. Its adjustment to the wearer is as simple as the garment itself, for it is wrapped once about the waist and hips, overlapped in front and the upper edge, especially the upper right-hand corner, is rolled and tucked inwards against the body. It is surprising how secure a fastening is thus obtained, and very quickly. On ordinary occasions this is all the clothing men and boys wear, but for church and other dress occasions a white close-fitting shirt is added. The white shirt, contrasted with the dark skin, and the bright lava-lava make a very becoming and picturesque costume. The usual dress for girls and women is a cotton "mother-hubbard," generally dull blue with white dots. This is serviceable, but not ornamental. Shirt waists and wash-dresses are the resource for special occasions, but these rarely have any definite relation to the figure of the wearer. Children and men generally go hatless, but occasionally a hat is a treasured possession and worn when occasion demands. Young women often wear hats to church, but tastes are catholic and there is no close adherence to style. Most of the hats have obviously seen better days.

THE CHURCH AT MER.

THE EVOLUTION OF FLOWERS

By JOHN H. LOVELL

WALDOBORO, MAINE

WHAT is a flower? This would seem to be an easy question for a botanist to answer; but, as a matter of fact, the definitions differ widely, and it has even been asserted that a strict definition is impossible. According to the German morphologist, Goebel, a flower is simply "an axis bearing sporophylls," that is, a stem with one or more modified leaves bearing spores. The fructifications of the horsetails and club-mosses would thus be regarded as flowers. This extension of the term is certainly not without its advantages, since it calls attention to the very ancient origin of floral structure and to its beginning among the primitive forms of plant life; but the strobili of the Pteridophytes are so unlike those of the Angiosperms and are so much older that to call both flowers is likely to prove confusing. Asa Gray and the older morphologists often speak of "the flowers" of the Gymnosperms; but the open carpel without style or stigma, as well as a difference of opinion in the case of several groups as to what constitutes a flower and what an inflorescence, are objections to this usage. Consequently it has been proposed to restrict the word flower to the Angiosperms, plants with a closed carpel, a part of which is specialized for receiving pollen. The term, as thus limited, has a very definite meaning, which can not be easily misunderstood even when the flower is reduced to a single stamen or pistil as among the aroids. This definition has also the advantage that it agrees with the popular conception of the word; and where possible for obvious reasons it is desirable that the definitions of science and of the non-scientific public should agree. The Angiosperms have been well called the Anthophyta, or flower-plants.

In the history of the evolution of plants the origin of the Angiosperms still remains an unsolved mystery. This great series makes its appearance suddenly in the Lower Cretaceous; and the fossil species exhibit no intermediate or transition stages, but possess all the essential characters of their modern representatives. There are a variety of comprehensive forms, it is true, which have been termed Proangiosperms; but there is no certainty that any of them are the actual precursors from which sprang the plants with a closed carpel. If, however, the Proangiosperms *de factu* were trees, as has been strongly advocated, there is good reason to hope that this knowledge will not always remain a secret of the rocks. But for the present any attempt to trace the

phylogeny of the Angiosperms must rest largely upon comparative morphology and conjecture; and so great is the fascination the problem offers that it is no exaggeration to say that every probable and improbable guess has been exhausted.

Vines formerly advanced the opinion that the Dicotyledons were descended from the conifers and the Monocotyledons from the cycads. Miss Benson, Hallier and Karsten have endeavored to trace back the Angiosperms, through the ament-bearing trees (Amentaceæ), to *Gnetum* of the Gnetales, an aberrant group of Gymnosperms. Campbell has suggested that the Monocotyledons may be connected with forms like *Isoetes,* as both have a single first leaf, and there are resemblances in the anatomical structure of the stem, leaf and root; but, he adds, that there is an immense interval between the simplest angiospermous flower and the sporophylls of *Isoetes.* Coulter has pointed out that *Selaginella* in its dicotyledonous embryo and the resemblance of the megasporangium to the seed condition is as suggestive of the Dicotyledons as *Isoetes* of the Monocotyledons; but an independent origin of both groups from *Marattia*-like ferns is favored. Others would reject a derivation both from the Gymnosperms and fernworts and seek for the beginning of the Angiosperms among the Bryophytes, or as a wholly independent phylum arising from the Algæ—one highly imaginative theorist, for instance, would derive the higher seed plants from the liverworts through apospory.

If these widely ranging speculations, of which only a very few are cited here, prove anything, it is that at the present time it is futile to look for the origin of the Angiosperms outside of the Gymnosperms. If they have come from a more primitive source, then we must be content to wait until the geological record shall be further revealed. As for the Gymnosperms themselves, it is established with reasonable certainty that they are descended from the Pteridophytes; and that their evolution extended over a long period of time, during which a great number of species became extinct. During the Mesozoic Age more especially in the Triassic, a remarkably equable climate prevailed over a large extent of the land surface of the globe, and gymnospermous trees were the dominant forms of plant life; conifers, maidenhair trees, cycads and cycadophytes in the greatest variety multiplied and developed every possible combination of cone structure. These vast forests must have displayed a foliage which in beauty of form has never been equalled, either before or since, in a terrestrial landscape. To suppose that contemporaneously another great phylum, which gave birth to the Angiosperms, was in existence, but of which not a vestige has been discovered, seems at least improbable. The morphological differences between the Angiosperms and the Gymnosperms, it is true, are so great that there is a strong tendency to regard them as entirely independent, nevertheless

the affinities between these two great series are much closer than between the Angiosperms and the Pteridophytes, *e. g.*, there can be no doubt, as Jeffrey insists:

> That the argument for descent from the Gymnosperms seems to gain great force from the entire absence of fernwort characters in the shorter leaves of the Angiosperms.

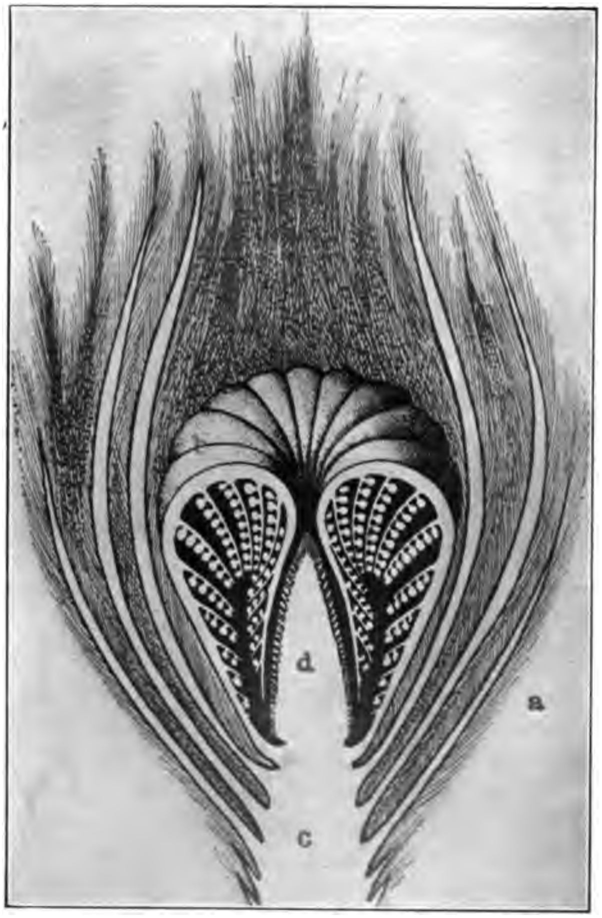

DIAGRAM OF STROBILUS OF *Cycadeoidea dacotensis*. (After Wieland.) *a*, hairy sheathing bracts; *b*, folded stamens; *e*, elongated axis; *d*, conical mass of sterile and fertile scales.

A few years ago the gymnospermous origin of the Angiosperms was temporarily believed by many to have been fully established when Wieland published his description of the bisporangiate cone of *Cycadeoidea dacotensis*, a fossil plant belonging to the extinct order Bennettitales. It was not supposed that *Cycadeoidea* was the direct ancestor of

the Angiosperms, but that the structure of its strobilus furnished decisive evidence of their derivation from an allied group as yet undiscovered. It was confidently hoped that the baffling mystery of the descent of the Anthophytes was about to be solved; and Arber and Parkin, taking Wieland's investigations as the basis of their work, sought to reconstruct the ancestral type of such flowers as *Magnolia.* The characters of the strobilus of *Cycadeoidea,* in the opinion of Scott, justify the conclusion that the Bennettitales were, of all known plants, the most nearly akin to the Angiosperms. The fructification of *Cycadeoidea,* which created a genuine sensation in the botanical world, must thus be regarded as the most interesting "flower" known to-day.

The strobilus of *Cycadeoidea,* as described by Wieland (see Fig. 1), was nearly five inches in length, with an elongated axis on which all the floral members, except the stamens, were spirally inserted. A series of densely hairy sheathing bracts, about three inches long, represented a primitive perianth. The bipinnate, frond-like stamens were united at base into a disc, and on the numerous pinnae there were two rows of pollen-sacs. The apex of the conical axis, prolonged above the stamens, was covered with a mass of fertile and sterile scales. The fertile scales were reduced to long slender stalks bearing terminal seeds containing dicotyledonous embryos. The interseminal sterile scales were club-shaped at the end and united by their distal edges into an envelope resembling a pericarp with a small central orifice out of which projected the micropyle, or open end of the seed. The flowers were anemophilous and the pollen came directly in contact with the seeds as in other Gymnosperms. If the large cones of this species, or of other Cycadophytes, displayed dull red or purple coloration, as is the case with many modern conifers and cycads, the Mesozoic forests were not entirely a somber monotonous green as is commonly supposed.

Guided by the strobilus of *Cycadeoidea* Arber and Parkin have endeavored to reconstruct the prototype of an angiospermous flower like *Magnolia.* This hypothetical "flower," or strobilus, is supposed to have been of large size, solitary, with the members spirally arranged on an elongated axis. The perianth was composed of an indefinite number of leaf-like bracts, which were probably green in color. The staminate organs may have been bi-pinnate fronds bearing two rows of pollen sacs upon the lateral leaflets; but it is more probable that they were very much reduced in size and that the lateral pinnæ had disappeared,—fossil stamens of a *Williamsonia* found by Wieland in Mexico had the number of pollen sacs reduced to two. The central fertile scales were broad, short leaves bearing a few ovules on their margins, a primitive stage still preserved by the carpellary leaf of *Cycas.* The strobili were pollinated by the wind as in all other Gymnosperms of this age. The effective

factor in transforming this ancestral form into a flower like *Magnolia,* according to Arber and Parkin, was the establishment of entomophily or insect visits. From this assumed prototype a *Magnolia* flower differs chiefly in that the stamens have lost their leaf-like character and bear only two anthers, while the open carpels have folded over the seeds and the pollen is received on a stigmatic surface. To both types are common the large size, the elongated axis and the spiral arrangement of the organs, except in the perianth of *Magnolia,* where the cyclic order might easily have been derived from the spiral.

In whatever light this hypothesis may be regarded, it is, at least, certain that the fossil *Cycadeoidea* never gave rise to an angiospermous species. The foliage alone presents almost insuperable difficulty, for while the Cycadophytes had simple bulbous or columnar trunks, surmounted by a crown of fern-like leaves, the Angiosperms branch freely and are microphyllous. Insects could not have been instrumental in bringing about such a transition; and Arber and Parkin endeavor to bridge the difficulty by the improbable supposition of a saltation or mutation. It is much more probable that the varied foliage of the Angiosperms finds an explanation in its physiological significance. Neither does the internal anatomy nor the structure of the gametophytes, according to Jeffrey, lend support to such a relationship. The carpel of *Cycadeoidea* is as truly gymnospermous as that of the cycads or conifers and is even more reduced, remaining only as a slender stalk; while the so-called pericarp, formed by the sterile scales, is not at all homologous with the closed carpel of the Angiosperms. But undoubtedly the strobili of the Bennettitales are helpful in suggesting the structure of the veritable Proangiosperms, which appear to be at present wholly unknown.

As already stated, Arber and Parkin regard the establishment of entomophily as "the motive force," which called the Angiosperms into existence and laid the foundation of their future prosperity. Scott likewise holds "that the rise and progress of the Angiosperms was probably due, above everything else, to their adaptation to the contemporary insect life." This is the generally accepted view, from which there seems to have been expressed no difference of opinion; but it is noteworthy that this theory was advanced chiefly by paleobotanists without extensive field experience in the observation of the phenomena of flower pollination. The reciprocal relations of flowers and insects are often truly wonderful and floroecology doubtless embraces more of romance than any other branch of botany. Entomophily could hardly fail to make a deep impression on the imagination of phylogenists in search of "motive forces"; but in the writer's opinion as a factor in the development of angiospermy it has been greatly overworked and forced to bear a burden greater than it can carry. As a matter of fact there probably were no insects deserving to be called anthophilous contemporaneous

with the beginning of the higher seed plants. Angiospermy must have arisen previous to the Cretaceous; and in the Cretaceous rocks the remains of very few insects have been found, the highest forms in America being those of beetles. As pollinators of flowers the Coleoptera are of little significance; and the development of the entomophilous flora would not have varied in any way in the absence of all anthophilous beetles. There seems to be no reason to suppose that flowers were visited by insects in the Jurassic Age, or that suitable species were in existence. The habit of anthophily was not quickly established; and it was long after the appearance of the primitive Angiosperms that the bees and butterflies were evolved.

But assuming, for the sake of argument, that there were anthophilous insects contemporaneous with the wind-pollinated Proangiosperms, let us inquire whether they could have induced the closing of the carpel. *Welwitschia,* a genus of the Gnetales, is entomophilous, but it still remains a Gymnosperm. If there are African cycads pollinated by insects, as Scott thinks probable, it has not led to angiospermy; nor is there any tendency toward such a modification in several living conifers which are frequently visited by beetles for pollen. Neither would the sporadic visits of unspecialized insects to the progenitors of the Angiosperms have been likely to have resulted in the development of angiospermy. The primitive open carpel must have been either uniovulate or multiovulate. If it were multiovulate then so long as it remained unclosed wind-pollination would have been more effective than insect-pollination, since the wind would be more likely to bring the requisite amount of pollen to many naked ovules than to a small stigmatic surface. The wind would also be a more reliable agent than the erratic visits of primeval insects, which might very rarely come in contact with the ovules of large strobili or of monosporangiate cones. In the case of the multiovulate carpel, so far as pollination in this age was concerned, the advantage would be greatly on the side of the open carpel and anemophily.

If, however, the carpel were uniovulate then obviously it could be equally well pollinated by the wind or insects, whether closed or open, indeed a lobed papillose stigma would offer a larger surface to the wind than would the micropyle of a single ovule. The inclosing of the carpel would here be independent of the question of pollination. For this reason the writer believes that the proangiospermous carpel was uniovulate, as it still is in many anemophilous and entomophilous primitive Angiosperms, *e. g.,* the wind-pollinated grasses and sedges, and largely in the Amentaceæ, and in the entomophilous *Alisma, Ranunculus* and *Fragaria.* In this connection it is noteworthy that the achenes of the Compositæ are one-seeded. The wide occurrence of uniovulate carpels among living Angiosperms would indicate that it was the prevalent

condition among the Proangiosperms, a conclusion supported by the commonness of carpels with a single ovule among the Gymnosperms. If the reverse had been true, it is highly improbable that the number of ovules would have been reduced after the establishment of entomophily; in the Ranunculaceæ the carpels of the primitive genus *Ranunculus* are uniovulate, while in the more highly specialized and later evolved genera *Aquilegia, Delphinium* and *Aconitum,* which are pollinated by bumblebees, the carpels are many seeded. One of the conditions, we hold, then on which the rise of Angiospermy was dependent was the uniovulate open carpel, which was equally well pollinated by the wind or by insects.

The rise of angiospermy was, therefore, independent of insects antedating the appearance of the anthophilous species, the visits of which did not become important until the higher seed plants were fully differentiated and the fundamental characters of foliage and flower determined. If the great plant groups the Cycadofilacales, Cordaitales, Cycadales, Bennettitales and Coniferales were successively evolved under anemophily, there is no inherent improbability in the Angiosperms also originating under wind-pollination.

Since the infolding of an uniovulate open carpel would be of no special benefit in pollination, and angiospermy has not been induced by entomophily it is very pertinent to inquire, in response to what conditions is it a reaction? It is undoubtedly one of the many structures, which have been developed to afford protection to the ovules and seeds in their various stages of growth. Cowles says:

> Adequate protection is especially important in monocarpic species, above all in annuals, since the maintenance of the species depends absolutely upon the viability of its seeds.

Throughout the spermatophytes the need of protection to the seeds is constantly emphasized. In the Cycadofilacales, where the ovules were borne directly on the margin of the sporophyll, they were often enclosed in husks or cupules. In the Cycadales, with the exception of *Cycas,* they are covered by the closely appressed cone-scales; while in *Cycadeoidea* protection was afforded by sterile, club-shaped, interseminal scales. In the Coniferales the seeds are on aborted shoots in the axils of the cone-scales, an advantage of so much importance that Saporta and Marion attribute the existence of the conifers to the development of the cone. Although Arber and Parkin regard angiospermy as a response to entomophily, they at the same time recognize that the closed carpel offers effective protection to the developing ovules. In the Proangiosperms small, uniovulate, open carpels were crowded on the apex of an elongated axis, as in *Magnolia,* where protection to the nascent ovules was most readily secured by the infolding of the carpel.

The involution of the carpel offers in itself very little difficulty, and there are numerous petals and leaves, which regularly or occasionally illustrate the origin of this modification. Abnormal cohesion of the margins of leaves is not unusual, and has been observed in the genera *Tilia, Corylus, Pelargonium* and *Antirrhinum,* and in the leaflets of the rose and strawberry. Phyllody of the pistils or their reversion to open leaves bearing ovules on their margins has likewise been recorded of many species. The protection of nectar from rain or useless insects has given rise to a great variety of tubular petals. In *Ranunculus auricomus* every intermediate stage between the open petal and the tubular nectary occurs; and in *Eranthis hyemalis* there is present a series of transitions between the outer flat perianth segments and tubular petals. Tubular petals are in some flowers the normal condition as in *Helleborus;* and they may occur where this form is apparently useless. Changes from strap-shaped to tubular corollas may often be observed in the marigold and aster; while in *Coreopsis tinctoria* one variety regularly has the rays tubular. In a variety of *Papaver bracteatum* the petals cohere to form a gamopetalous corolla. Undoubtedly tubular nectaries have been developed independently in widely separated families; and it is not improbable that angiospermy may have originated more than once. The carpel did not at first close entirely, but the apex was filled with a mucilaginous liquid, which served to retain the pollen until the development of a stigmatic surface—such a mucilaginous drop is found in the micropyle of coniferous ovules. The subsequent development of the style permitted the relative position of the stigma to be changed; the filaments performing a similar service for the anthers.

How long an interval elapsed after the origin of angiospermy before entomophily was established it is impossible to say; but the evolution of the bees, or Anthophila, the most important of all the anthophilous groups, must have been a comparatively modern event. The first flower-visiting insects were synthetic types without special adaptations for gathering pollen or nectar; and their attentions were, of course, forced upon flowers and not the result of allurements offered to secure their services. In the writer's opinion pollen was the first source of attraction. To suppose that the fructifications of the Proangiosperms contained nectar is purely an assumption, since there is no reason to believe that the strobili of the anemophilous Gymnosperms were ever nectariferous, or that nectar was common in flowers until after the rise of entomophily. Moreover, an examination of anthophilous insects shows that they became progressively specialized from pollen-eaters to nectar-feeders. Of the beetles seeking flower food *Trichius affinis, Euphoria inda* and various Coccinellidæ manifest a preference for pollen; while the genera *Nemognatha* and *Gnathium* live wholly on nectar, for procuring which the maxillæ have become modified into a suctorial tube.

Among Diptera the Syrphidæ and Muscidæ consume both pollen and nectar, while the Bombylidæ and Empididæ feed entirely on nectar. The short-tongued bees belonging to the genera *Prosopis, Sphecodes, Halictus* and *Andrena* still eat pollen; but adult honey-bees are wholly dependent on honey, and in its absence a colony will starve although there is an abundance of pollen in the combs. The evidence favors the view that anthophilous insects began by eating pollen, and that the secretion of nectar and its use as a food were events of later date. In their relations to a floral diet, adult beetles and flies may be divided into four groups: (1) species which never visit flowers or only accidentally; (2) species which are partly predaceous or phytophagous and partly anthophilous; (3) species which live on pollen and nectar exclusively; (4) species which live on nectar alone.

The pollen of anemophilous flowers is still gathered by both the smaller and larger bees and devoured by beetles and flies. According to Henslow there is no pollen grain so smooth that the hairs on the limbs of a bee or fly can not hold it, even the pollen grains of grasses, though smooth in water, when dry are notably wrinkled into sharply angled and irregular shapes. Small Syrphid flies have been observed by the writer resorting regularly in the morning to the flowers of the common herd's grass for the purpose of feeding on the pollen. While honey-bees to-day more often gather pollen from anemophilous flowers than the solitary wild bees, this is obviously an artificial relation incidental to the many large apiaries maintained for the production of honey and wax, which contain thousands of workers and require immense quantities of pollen for brood-rearing. At the time of the beginning of entomophily the Anthophila were not in existence. Unlike all other tribes of insects, the bees are wholly dependent on pollen for brood-rearing, and the acquisition of this habit must have been an important factor in determining the course of their development. The pollen of entomophilous flowers has acquired adhesiveness and a rough or spinose surface, which greatly facilitates its transfer by insects from one flower to another.

While insects were first attracted to flowers by pollen, nectar secretion offered a stronger allurement and gave a new impulse to entomophily. Nectaries occur on the foliage of a great variety of plants, even on the stalks of ferns (*Pteris*), as well as in flowers; and its secretion is primarily a function independent of insects. Leaves secrete and excrete a great variety of products, and besides nectar glands may possess water-glands, chalk-glands and slime-glands. Since transitions between water-glands and nectar-glands occur, it can not be certainly affirmed, says Cowles, that the secretion of nectar by leaves is other than a waste product. The appearance of nectar-glands, at least occasionally, on the modified leaves of entomophilus flowers would be wholly in accordance with expectation; and their value in attracting insects would ensure

their preservation. The need of protection from wet and robber insects subsequently resulted in the development of nectaries. In more recent times this function in my opinion has been lost by various pollen flowers, as *Anemone, Rosa* and *Desmodium,* and nearly so by the mulleins.

Besides an adhesive pollen and nectar secretion there are correlated with entomophily bright coloration, attractive odors, and a great variety of mechanisms for the transfer of pollen through insect agency. Except to a very limited extent these characters do not belong to wind-pollinated flowers, and in the absence of insects there is no satisfactory evidence that they would have ever been developed. On the contrary with the cessation of insect-visits they may be speedily lost and the flowers revert to anemophily, as in *Artemisia.* Among the older floroecologists it was practically the universal belief that the structural modifications enumerated were purposive adaptations to ensure cross-pollination. Adaptation in this sense is now regarded as akin to vitalism and its validity denied. It may be admitted that plants do not possess an inherent power of producing structures because they are needed, that natural selection has been given too wide an application, that other factors have been important in the development of flowers, as orthogenesis, mutation and, in view of the probability that many species are hybrids, as held by Lotsy and Jeffrey, Mendelian laws of inheritance. But while many minor and extreme structures of flowers may be due to special factors, the hypothesis that the general trend of floral evolution has been determined by the preservation of advantageous variations, whatever their origin, by natural selection offers the field ecologist a tenable working theory better than any other available.

Difficult as is the problem of the origin of flowers, a solution is far from hopeless.

> By past efforts unavailing,
> Doubt and error, loss and failing,
> Of our weakness made aware,

there is nevertheless no other course left for the phylogenist than to continue "trying with uncertain key door by door of mystery." The great success of the paleobotanist in tracing the descent of the Gymnosperms awakens the hope that fossil records will yet be discovered, which will throw new light on the evolution of the Anthophytes. Let us await the testimony of the rocks.

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THE ELECTROMAGNETIC THEORY OF LIGHT

By Professor DAVID VANCE GUTHRIE
LOUISIANA STATE UNIVERSITY

OF the many striking advances which marked the progress of physical science in the past century, two stand out as preeminently the greatest and most far-reaching—the discovery of the principle of the conservation of energy, and the promulgation and verification of the electromagnetic theory of light. Many other discoveries of the highest interest and greatest value were made, but these two stand apart as the crowning achievements of nineteenth-century physics. While a knowledge of the former of these principles has become widely diffused, we find quite the reverse to be true with regard to the latter. The "conservation of energy" has become a household phrase, while, on the other hand, there are very few to whom the "electromagnetic theory of light" is more than a meaningless expression. This lack of acquaintance on the part of the general public with one of the most interesting developments of modern scientific theory is doubtless due in large part to the fact that there has been little attempt up to the present time to present the essentials of the theory in simple form and in non-mathematical language, so as to be readily intelligible to the average well-informed reader. The story of the successive steps in the development of the theory and of the various experiments which have served to establish it on a firm basis forms one of the most fascinating chapters in the annals of modern science, and it is the purpose of the present article to recount the chief of these steps as well as to outline briefly the essential features of the theory.

The speculations of the ancients as to the nature of light strike our modern fancy as fantastic and grotesque. Many of the philosophers of antiquity advocated the view that we see bodies by means of rays proceeding from the eye to the object of vision rather than in the contrary direction. None of the theories proposed rested upon any basis of scientific fact. The first serious attempt to answer the question as to the nature of light seems to have been in the time of Newton. At this time two conflicting theories arose; the corpuscular theory, and the undulatory, or wave, theory.

Those who held to the former theory advocated the view that luminous bodies are continually emitting streams of small particles traveling with very high velocity, like tiny bullets, which, on entering the eye, produce the sensation of sight. Simple though the theory may appear at first sight, it was soon found that in its general application diffi-

culties are encountered which can only be surmounted by resorting to hypotheses which seem extremely strained and artificial. Newton himself stood sponsor for the corpuscular theory, and it is evident that the weight of his opinion maintained it in the ascendancy much longer than if it had been left to stand or fall on its own merits. Until the close of the eighteenth century this was the theory generally accepted.

The wave theory, according to which light consists of waves traveling through a medium of some sort rather than a stream of material particles, was elaborated by Newton's contemporary, Huyghens, and in many respects seemed more closely in accord with the results of experimental evidence than the corpuscular theory. At that time, however, positive evidence serving to discriminate between the two theories was lacking. Such evidence was furnished many years later by the establishment of the fact that light travels more slowly in dense than in rare media; a result in accord with the predictions of the wave theory, but directly opposed to the consequences to which the corpuscular theory would lead us. This evidence was not available in the seventeenth century, however, as no practicable method of determining the velocity of light in different media had been devised at that time. Newton seems to have been led to reject the wave theory because of the fact that light does not appear to bend around the corners of an obstacle as do sound waves or water waves. This premise we now know to have been a mistaken one, for the beautiful diffraction experiments of Fresnel proved that light does bend around the edges of a body as do other types of waves. The effect is less noticeable the shorter the length of the wave, however, and in the case of light waves is only rendered manifest by such phenomena as those of diffraction. Finally, in 1801 the wave theory became definitely established through the classic experiments of Thomas Young on interference.

To have proved that light consists of waves, however, is to have advanced only a short way toward the complete solution of the problem. It is at least equally important to settle the question as to what kind of waves light waves are. In every type of wave motion it is essential that we have a medium and a disturbance of some sort traveling through this medium. So we have not learned much as to the true nature of light until we are able to give some account of the nature of the medium which serves to convey light waves and of the character of the disturbances which are set up in it.

The questions as to the nature of the medium and the character of the disturbances are linked closely together, for upon the properties of the medium will naturally depend the type of disturbance which that medium is capable of transmitting. Certain properties of the medium which must be supposed to exist in order to account for the phenomena of light were manifest from the first; certain characteristics which

made it evident that the medium in question must differ in many respects from ordinary matter. It must fill all space and at the same time must be tenuous in the extreme, since the planets and other heavenly bodies move through it without having their motion retarded in the slightest degree. It must also be capable of acquiring and transmitting energy, both potential and kinetic. To this medium was applied the name "the luminiferous ether."

One of the most common types of wave motion is that found in elastic solid bodies, and in many respects there seemed to be a similarity between light waves and the waves in such bodies. Accordingly, the "elastic solid theory" arose, which attributed to the ether the properties of an elastic solid and assumed that ether waves were similar to the waves set up in bodies of this character. The properties of such waves are familiar and their velocity can always be expressed as a function of the density and of the elasticity of the medium. The theory furnished a simple and satisfactory explanation of the majority of optical phenomena and seemed a long step toward the solution of the problem as to the nature of light.

There were certain implications of the theory, however, which seemed to necessitate somewhat violent assumptions as to the properties of the ether. The velocity of waves in elastic bodies is $\sqrt{E/d}$, where E represents the elastic modulus of the medium and d its density. Now since light travels through the ether at the enormous velocity of 300,000 km. per second, it follows that E must be very great or d extraordinarily small. But the assumption of a medium with density far below that of any known material substance, and at the same time with elastic properties comparable with those of steel, involves obvious difficulties. Nor was this the chief difficulty. The phenomena of polarized light proved beyond a doubt that light waves are transverse waves. Nowhere was there any evidence of the existence of longitudinal waves in the ether. An elastic solid, however, must be capable of transmitting either longitudinal or transverse waves. So various theories were proposed to account for the absence of longitudinal ether waves, one of the most prominent being Lord Kelvin's "labile ether," which was supposed to have a negative elastic modulus, and which, if not supported in some manner at the outer boundary, would tend to contract. But all these theories were more or less artificial, and none of them seemed to furnish a satisfactory solution of the difficulties which they were designed to remove.

From a study of the phenomena of electricity and magnetism evidence was accumulating that a non-material medium must be invoked to account for the fundamental facts in those fields also, but there was nothing to show that the medium which served as the basis for electrical and magnetic forces was identical with the "luminiferous ether," nor

had the study of these phenomena thrown any light on the problems which had arisen with regard to the nature of the ether.

Such was the state of affairs when James Clerk Maxwell, in 1864, by a supreme stroke of genius, advanced the theory which has served to link together two great branches of physical science and to bring order out of a chaos of apparently unrelated facts. Proceeding upon a basis of facts derived from a study of electrical and magnetic phenomena (a foundation laid for the most part by Faraday), Maxwell showed that electromagnetic disturbances, originating at any point in space, should be propagated in all directions through the ether, not instantaneously, but with a finite velocity which could be calculated by means of certain equations which he derived. The value of this velocity thus calculated came out 3×10^{10} cm. per second. At once the identity between this figure and the velocity of light as determined by several independent methods was strikingly apparent and led to the suspicion that light might be a disturbance of electromagnetic nature traveling through the ether in accordance with the laws governing such disturbances.

On the basis of this fact alone, however, the agreement between the two figures might be set down as a coincidence—a striking one, it is true, but not beyond the bounds of possibility. But Maxwell went much further than this, and showed that an oscillating electric charge should give rise to a wave motion in the ether answering in all essentials to the known properties of light waves; that these waves, consisting of an alternating electric field accompanied by an alternating magnetic field at right angles to it, and hence known as electromagnetic waves, should in case of incidence on a material medium be either reflected, refracted, or absorbed by that medium, just as light waves are.

Another very important fact was evident from Maxwell's equations—the alternating electric and magnetic fields which constitute the waves are necessarily in a plane perpendicular to the direction in which the waves are advancing; in other words, electromagnetic waves are transverse waves. Now this we have seen to be one of the essential characteristics of light waves and one which can not be satisfactorily explained on the elastic solid theory. By making the assumption that light waves are electromagnetic waves, Maxwell was thus able to account for their transverse character, to explain in a satisfactory manner all the fundamental phenomena of light, and to predict a most striking interrelation between the electrical and the optical properties of a body.

The electromagnetic theory of light as worked out by Maxwell seemed a plausible and, on the whole, a satisfactory solution of the problem as to the nature of light, but it could hardly take its place among the rank of established theories without actual experimental evidence of the existence of electromagnetic waves. Such evidence was not forthcoming until more than twenty years after Maxwell proposed the theory.

In 1888 Heinrich Hertz, in a series of brilliant researches, succeeded in producing electromagnetic waves in the laboratory and in showing that these waves possessed the characteristic properties which Maxwell had predicted. In Hertz's classic experiments two polished knobs, each attached to a rectangular metal plate, were connected to the secondary terminals of an induction coil and brought near each other. When a spark was allowed to pass between them, and a loop of wire with small adjustable spark gap was brought in the neighborhood, a tiny spark was observed in this second and independent circuit. The device for producing the original spark Hertz called the oscillator and the loop of wire the resonator. In order to prove that the effect observed was due to the radiation of some form of wave motion from the oscillator, Hertz formed stationary waves by placing a large metallic plate at some distance from the oscillator, and on moving the resonator gradually from the oscillator to the plate, found that the effect showed well-marked maxima and minima at regular intervals. A spark discharge such as is obtained in Hertz's oscillator has been shown to be oscillatory in character, and it is apparent from the experiment just described that such an oscillatory discharge sets up a wave motion of an electrical nature in the surrounding space which is reflected from the metal plate, resulting in the formation of stationary waves. By measuring the distance between successive "nodes" Hertz was able to determine the wave-length of the waves; from the dimensions and other characteristics of the oscillator it is possible to ascertain the frequency of vibration; then, knowing that in any type of wave motion the velocity is equal to the product of the frequency and the wave-length, it may be proven that the velocity of these electrical waves is 3×10^{10} cm. per second, the same as the velocity of light. Hertz showed that these waves, which were evidently the electromagnetic waves predicted by Maxwell, could be reflected, refracted and polarized; that they exhibited the phenomenon of interference; in short, that they possessed all the characteristic properties of light waves, the only difference between these waves and those which affect the optic nerve being a difference in wave-length. From a practical standpoint Hertz's discovery was of the utmost importance, for it marked the inception of modern wireless telegraphy. Other important consequences of the electromagnetic theory, which will be described presently, were confirmed later, but the original work of Hertz was sufficient to show that Maxwell's theory was in thorough accord with experimental evidence and thus to place the theory on a firm basis.

Before going further into the implications of the theory, let us see just what it postulates as to the nature of light. It is a familiar fact that a changing magnetic field gives rise to an induced electromotive force at right angles to its own direction. It is equally well known that

an electric current, or what amounts to the same thing, the motion of lines of electric force, sets up a magnetic field at right angles to the direction of these lines. An alternating electric field is then necessarily accompanied by an alternating magnetic field perpendicular to itself, and vice versa, each field attaining its maximum while the other is passing through its zero value. An electric charge at rest is surrounded by a stationary electric field; if it is caused to oscillate, it sets up an oscillating electric field at every point in the surrounding space, accompanied by an oscillating magnetic field at right angles to it. These electrical and magnetic disturbances travel outward in all directions through the ether at the enormous velocity of 300,000 km. per second, the electrical and magnetic fields being always at right angles to the direction in which the disturbance is traveling. The higher the frequency of the oscillations, the shorter will be the distance between two successive disturbances, or the wave-length. Only when the oscillations are taking place at an extremely rapid rate does the length of the waves become short enough for them to affect the human eye. Such is our conception of a light wave on the electromagnetic theory.[1]

The vast importance of the part which electromagnetic waves play in nature may be appreciated from the fact that within the group are included the entire range of radiations known as X-rays, gamma rays, ultra-violet rays, visible light of various colors, infra-red rays, heat waves, and the long waves used in wireless telegraphy. The inclusion of the first-named rays within the group must be counted one of the most remarkable achievements of experimental science in the present decade. The researches of Laue, the Braggs, and Moseley on the diffraction of X-rays by crystals have proven that X-rays consist of very short ether waves, having a wave-length of the order of magnitude of an Ångström unit (an Ångström unit being the ten-millionth part of a millimeter). In fact, the most recent work indicates that under certain conditions X-rays may be produced having a wave-length even shorter than a fifth of an Ångström unit. The gamma rays given off

[1] It will be noted that the so-called " displacement currents " which play so prominent a part in Maxwell's development of the theory have not been mentioned. It is difficult to form a clear conception of the exact nature of displacement currents, so that a discussion of them would be out of place in an elementary presentation. Moreover, however important may be their part in the mathematical development of Maxwell's equations, it is at least open to question whether we may not leave them out of account in formulating a statement of the essential characteristics of an electromagnetic wave. For certainly the outstanding features of such a wave are the alternating electric field accompanied by the alternating magnetic field. We are at liberty, if we choose, to invoke displacement currents set up by the electric field as an intermediate stage necessary to the production of the magnetic field, but the electric and magnetic fields are undoubtedly the fundamental facts upon which we are to fix our attention.

by radium and other radio-active bodies, being essentially X-rays, have wave-lengths of the same order of magnitude, but even shorter, the wave-length of the gamma rays being only about one tenth of an Ångström unit. Between the X-rays and the shortest ultra-violet rays so far obtained lies a gap, as yet unexplored. The region of very short waves of ultra-violet light, first investigated by Schumann, has been greatly extended toward the short wave-lengths by Lyman, who has been carrying on some notable work in this region and has just succeeded in measuring wave-lengths as short as 600 Ångström units or 0.00006 mm. His success in this field encourages the hope that the limit may be pushed much further and the gap entirely bridged before long. The region of the spectrum lying between 600 and 3,900 Ångström units comprises the ultra-violet rays, so-called because they lie just beyond the violet of the visible spectrum. These rays are entirely invisible to the human eye, but produce chemical action and affect a photographic plate quite readily. From 3,900 to 7,600 Ångström units (0.00039 to 0.00076 mm.) we have the visible spectrum, ranging from violet, the shortest visible rays, to red, the longest. Beyond the red end of the spectrum we have the infra-red rays, which do not affect the eye, but which convey radiant heat and are frequently known as heat waves. It is these waves, together with those of the visible spectrum, which bring to us from the sun the tremendous and unfailing stream of energy without which no life could exist on earth. This region of the spectrum has also been greatly extended in recent years, first by Rubens and his co-workers, using the method of "rest-strahlen," which enabled them to investigate waves as long as 0.06 mm., and more recently by Wood and Rubens, who used the ingenious method of focal isolation, by means of which they succeeded in obtaining the longest infra-red waves so far discovered. The longest waves obtained by this method had a wave-length of about 0.34 mm., while the shortest Hertzian waves, as produced by Righi, measure about 3 mm., leaving an unexplored region of comparatively narrow extent. Then come the electromagnetic waves produced by electrical means and varying in length all the way from the short ones produced by Righi to the very long ones used in radio-telegraphic work. The waves actually employed in this work vary from 100 meters in length or less to 10,000 meters or more.

It follows, then, that the longest known electromagnetic waves are more than one hundred trillion (10^{14}) times as long as the shortest ones. There are few of the facts revealed by the progress of modern science which make a more striking appeal to the imagination than this tremendous range of waves, varying in length all the way from those so small that hundreds of millions of them would be required to cover an inch to those several miles long; all of them essentially the same in character and obeying the same fundamental laws, but affecting us in

different ways according to their length—some of them affecting the optic nerve and revealing to our eyes all of the various colors of nature, some of them conveying to us the heat of the sun, some producing chemical effects or making an impression upon a photographic plate, some penetrating with ease bodies which are opaque to ordinary light, some healing diseases, while yet others serve to bring us messages from the ends of the earth.

It is instructive to vary our point of view by arranging this long scale in octaves, as is done in the case of the musical scale. Upon doing this we find that the whole range covers just about 48 octaves, of which the visible spectrum comprises only one! Starting with the shortest of all, the gamma rays of radium, we have a range of about four octaves, including the gamma rays and the different types of X-rays. Then comes a space of something over nine octaves, as yet unexplored. The ultra-violet group, including the waves studied by Schumann and by Lyman, follows, embracing somewhat less than three octaves. The single octave comprising the visible spectrum is next in order. The infra-red group occupies between eight and nine octaves, followed by a scant three constituting our second unexplored region. The remaining twenty or twenty-one octaves are occupied by the Hertzian waves, only the last seven, however, being made use of in wireless telegraphy. It is encouraging to note the small extent of the two gaps in our scale in comparison with the vast range which we have been able to study. It is not unreasonable to suppose that these two gaps will be entirely bridged in the near future, and that we shall be able to produce and study at will any wave-length desired from the gamma rays to the longest Hertzian waves.

There are many important consequences of the electromagnetic theory which may readily be subjected to experimental test. Chief among these are the intimate relations which according to the theory must exist between the electrical and the optical properties of a body. When waves pass from one medium to another they undergo refraction, the amount of the bending which occurs depending upon the ratio of the velocities of the waves in the two media. This ratio of velocities is termed the index of refraction of the one medium with reference to the other. But according to the electromagnetic theory the velocity of these waves in any medium is equal to $V/\sqrt{e\mu}$, where V represents the velocity of the waves in the ether, e the dielectric constant of the medium and μ its magnetic permeability. We may assume without sensible error that the magnetic permeability of any ordinary transparent medium is unity, from which it follows that $V/V' = \sqrt{e'}/\sqrt{e}$ for any two media. Since the dielectric constant of the ether may be taken as unity, it may readily be seen that the index of refraction of any material medium should be numerically equal to the square root of its dielectric constant. Thus we have an important relation between

the electrical and the optical properties of a medium, which may readily be subjected to experimental test.

In applying this relation to a specific case, however, two important facts must be kept in mind. The index of refraction of a given medium is by no means a constant, but varies with the wave-length, approaching a limiting value in the case of very long waves.[2] Neither is the so-called "dielectric constant" really a constant, as the name implies, but it varies to a certain extent with the frequency of the applied electromotive force. In actual practise it is usually determined by applying a steady electromotive force, while in the case of a light wave the alternating electric field is oscillating with an almost inconceivably high frequency. In view of these facts it is not surprising that there are many cases where the relation does not hold good when the ordinary values of the index of refraction and of the dielectric constant are used. There are several cases, however, in which we have striking agreement, even with the use of the ordinary values, as shown by the following table.

	n	$\sqrt{e}$
Air	1.000294	1.000295
Hydrogen	1.000138	1.000132
Carbon dioxide	1.000449	1.000473
Carbon bisulphide	1.637	1.634
Benzine	1.50	1.54

In the case of many substances which have values for these constants not in accord with the predictions of the theory, using the ordinary values, we find that the agreement becomes striking when we use the value for the index of refraction which applies to very long waves. Thus for water $\sqrt{e} = 8.95$ and $n = 1.334$, using yellow light. But it has been found by Fleming and Dewar that the index of refraction of water for very long waves is 8.9, approximating closely to the value of $\sqrt{e}$ given above. For flint glass $\sqrt{e}$ lies between 2.6 and 2.8 and $n = 1.62$, using yellow light, but for long waves $n = 2.6$. So that it seems entirely probable that if we could determine the values of n and e under precisely similar conditions the relation would be exactly verified in every case.

When electromagnetic waves fall upon a body which is a non-conductor of electricity, they are refracted, the amount of deviation which

[2] The variation in the index of refraction with the wave-length may be accounted for by assuming the presence in dielectrics of "bound electrons," having certain natural periods of vibration. When light waves fall upon the body, resonance effects are produced by these electrons which affect the velocity of the waves, the effect naturally being greater the more nearly the period of the waves coincides with those of the electrons. The periods of these electrons may be determined from the position of the absorption bands in the spectrum of the substance, and by modifying our theory to take into account their effect we may derive a dispersion formula which represents the index of refraction of the substance for waves of all lengths.

they suffer depending, as we have seen, upon the electrical and magnetic properties of the body. When they are incident upon a conductor, on the other hand, the alternating electric field causes rapidly alternating currents to flow in the surface of the conductor and these currents quickly absorb the energy of the waves. It is an important consequence of the electromagnetic theory, therefore, that conductors of electricity should be opaque to light and non-conductors transparent. In a general way this prediction is confirmed, for the metals, which are the best conductors we have, are also the substances most opaque to light, while many of the best insulators, such as glass, are quite transparent. Certain crystals, such as tourmaline, conduct electricity better in one direction than in another. In such crystals the transparency to light is found to vary accordingly. Most of the exceptions to the rule are explainable upon obvious grounds. For instance, water, although transparent, is a conductor of electricity under ordinary conditions. Water of absolute purity, however, is one of the best of insulators. The opacity of such non-conductors as wood, paper, etc., is explainable on the ground of lack of homogeneity in structure. Many of these substances, such as hard rubber, which are opaque to ordinary light, are quite transparent to the longer infra-red rays. Another apparent exception is found in the case of electrolytic solutions which are conductors of electricity and yet are transparent. It is to be noted, however, that the carriers of the electric current in this case are ions, having a mass very large in comparison with that of the "free electrons" which are responsible for metallic conduction, that they are consequently unable to respond to the rapid oscillations of the electric field in the electromagnetic wave and the wave is therefore not absorbed. In many cases dielectrics possess "bound" electrons or ions having characteristic periods of vibration; if a wave of precisely this frequency falls upon the substance these ions are set in vibration, thus absorbing the energy of the wave; in this way absorption lines or bands are produced in the spectrum when light is passed through the substance.

Another important consequence of the electromagnetic theory which has been fully confirmed by experiment is that light waves should exert a pressure on objects upon which they fall. Maxwell showed that electromagnetic waves must exert a pressure of definite amount, though quite small, upon a surface which absorbed them, and a pressure of double this amount on a reflecting surface. The amount of this pressure, in the case of the light we receive from the sun, he calculated to be less than a dyne per square meter of surface. On account of the smallness of the effect it eluded observation for a long time, but finally Lebedew, of Moscow, in 1900, succeeded not only in detecting this pressure due to light, but in measuring its amount, which he found to agree, within the limits of experimental error, with the value predicted by

Maxwell, thus affording one of the most notable verifications of the electromagnetic theory so far obtained. Nichols and Hull, in the United States, independently obtained the same result.

But however striking the facts we have cited, there is a link missing in the chain of evidence which supports the theory until we have succeeded in tracing the source of the electromagnetic disturbances which constitute light waves. Hertzian waves are set up by an oscillatory discharge of electricity; but where are we to find the oscillating electric charges which the electromagnetic theory calls for as the source of light waves? For many years after the theory was proposed this question was unanswerable; but with the advent of the electron theory a simple and obvious solution presented itself. According to the electron theory, the atoms of matter, instead of being the ultimate units, as was so long supposed, are made up of much smaller particles called electrons, the electron having a mass equal to about $1/1800$ of that of the hydrogen atom. The electron always carries a negative charge, and instead of being fixed in position is in continual and extremely rapid revolution about the positive nucleus of the atom in much the same way that the planets revolve around the sun in the solar system. Here then we have an oscillating electric charge, which must perforce set up an electromagnetic wave, on a vastly smaller scale, but otherwise the same as that produced by a Hertzian oscillator. It will be readily seen that the vibration frequency of these electrons must be almost inconceivably high, for dividing the velocity of light waves by the wave-length of red light we get for the frequency of vibration of the electron when sending out red light $\frac{3 \times 10^{10}}{7 \times 10^{-5}} = 4.28 \times 10^{14}$, or over four hundred trillion times a second, and similarly for blue light we get eight hundred trillion (8×10^{14}) times a second. When we recall the extreme smallness of the electron, even as compared with the atom, it will be apparent that there is nothing inherently improbable in these enormous values for the vibration frequency, however much they may tax the imagination, for in general the smaller the dimensions of the oscillator, the more rapid are the vibrations which it is capable of executing.

In bodies at ordinary temperatures the vibrations are much slower than this and long heat waves are sent out; as the bodies are heated and the molecules vibrate more rapidly the electrons within the atoms are also set in more rapid vibration and shorter and shorter waves are sent out; finally, when the vibration frequency becomes high enough, visible light is produced. It is a familiar fact that luminous gases give line spectra, indicating that certain definite and characteristic wave-lengths are sent out, whereas incandescent solid and liquid bodies give continuous spectra, all the wave-lengths from red to violet being represented. This is in line with what we should expect on our theory, for the electrons in the molecules of gases are free to vibrate in their natural

periods on account of the relatively long intervals elapsing between molecular collisions; whereas in solid and liquid bodies the electrons are continually being disturbed by the frequent impact of one molecule against another and so vibrate in all possible periods, thus giving rise to a continuous spectrum.

Although the electron theory contributed a great deal toward the establishment of the electromagnetic theory of light in that it indicated a probable source of the electromagnetic waves sent out from luminous bodies, we can hardly claim to have proved that the vibrating electron is the actual source of a light wave until we have actually obtained data as to certain of the most important characteristics of the vibrating source and shown that they are in accord with the data obtained as to similar properties of the electron. This has been achieved through a study of the well-known Zeeman effect. It was shown by Zeeman in 1896 that when a source of light is placed between the poles of a strong electromagnet, the lines in its spectrum break up into more or less complex groups of lines. To take one of the simplest cases, when the spark formed between cadmium electrodes is placed in a strong magnetic field and the light examined spectroscopically, the green line which is always conspicuous in the cadmium spectrum is observed to break up into two lines, one on each side of the normal position of the line, when the light is passed along the direction of the magnetic field; when viewed transversely, a triplet is formed. It may be readily shown that these are exactly the effects we should expect if we assume an electron revolving in an orbit as the source of the light waves. A magnetic field perpendicular to the plane of the revolving electron would cause a slight increase or decrease in the speed of the electron in its circular path, thus causing a slight change in the wave-length emitted with corresponding displacement of the spectrum line. The components into which the lines are broken up are found to be polarized, and by observing the direction of polarization in each component it can be shown that the vibrating source must carry a negative charge; further, by measuring the amount of separation of the components the ratio of the charge to the mass of the vibrating particle may be calculated. The value thus obtained agrees so closely with the corresponding ratio for the electron as obtained by a number of different methods that there is no longer room for doubt that light waves are electromagnetic waves set up by the revolution of the electrons within the atoms of material substances.

We may sum up the principal steps in the development of the electromagnetic theory as follows:

1. Maxwell in 1864 predicted the existence of electromagnetic waves and calculated on the basis of purely electrical data the velocity these waves should have. The resulting value proved to be the same as the velocity of light. These waves he showed should be transverse waves,

and should be capable of being reflected, refracted, and polarized just as light waves are.

2. Hertz in 1888 succeeded in producing these electromagnetic waves experimentally. Their velocity has been found to be 3×10^{10} cm. per second, the same as the velocity of light. By actual experiment Hertz showed that these waves were susceptible of reflection, refraction, and polarization and in all essential properties were identical with light waves.

3. The whole range of electromagnetic waves with which we are familiar extends all the way from the gamma rays of radium to the very long waves used in wireless telegraphy, a range of nearly 50 octaves, with only two comparatively small gaps in the scale. One of these regions of waves as yet undiscovered lies between the longest X-rays and the shortest ultra-violet rays; the other between the longest infra-red rays and the shortest Hertzian waves.

4. The electromagnetic theory calls for a very intimate relationship between the electrical and the optical properties of a body and in many cases experimental investigation gives results in close agreement with the predictions of the theory, as in the case of the connection between the opacity of a medium and its electrical conductivity, and between the index of refraction and the dielectric constant.

5. Maxwell, on the basis of his theory, predicted that light should exert a pressure on objects upon which it falls and calculated the amount of this pressure. This effect has been detected by Lebedew in Russia, and by Nichols and Hull in the United States, and found to be equal in amount to the value predicted by Maxwell.

6. The electron theory first furnished an answer to the problem as to the origin of the electromagnetic disturbances which constitute light waves, indicating the vibrating electron within the atom as the probable source. That this explanation is the correct one has been proven in a striking manner by the Zeeman effect, or resolution of spectral lines when the source of light is placed in a strong magnetic field. By means of measurements of this effect it has been proven that the vibrating source must carry a negative charge and that the amount of this charge is identical with that which the electron is known to possess.

In view of the facts which have been cited we can hardly fail to accord to the electromagnetic theory of light a place of preeminence among the achievements of physical science in the past century. Probably no other theory in the whole field of physics has served to coordinate so large a number of apparently unrelated phenomena. Two of the great branches of physics, electromagnetism and optics, have been made one; our insight into the processes of nature has been vastly broadened; and research in quest of an explanation of the more fundamental problems of optics has been both stimulated and directed by this wonderful theory, which will always stand as an enduring monument to the genius of Maxwell.

THE EXPERIMENTAL METHOD AND SOCIOLOGY

By Professor F. STUART CHAPIN

SMITH COLLEGE

The Theory and Practise of the Experimental Method

SINCE the time of Comte, sociologists have been searching for a method to apply to the data of society which would yield as positive results as those attained in the realm of physical science. The experimental method has contributed in large measure to the striking achievements of modern science. This method allows us to analyze out relations of cause and effect more rapidly and clearly than by other methods. It permits verification by many observers. It has substituted for unreasonable prejudice a definite sort of proof that has attained sufficient certainty to justify prediction.

Experiment is simply observation under controlled conditions. When observation alone fails to disclose the factors that operate in a given problem, it is necessary for the scientist to resort to experiment. The line between observation and experiment is not a sharp one. Observation tends gradually to take on the character of an experiment.[1] Experiment may be considered to have begun when there is actual human interference with the conditions that determine the phenomenon under observation.[2]

The fundamental rule of the experimental method is to vary only one condition at a time and to maintain all other conditions rigidly constant.[3] There are two good reasons for this procedure: in the first place, if two conditions are varied at one time and an effect is produced, it is not possible to tell which condition is responsible, or whether both have acted jointly; in the second place, when no effect ensues, how can we tell which condition is responsible, or whether one has neutralized the other?[4]

Specific illustrations from the fields of physics, botany and psychology may serve to bring the principle to mind. Newton desired to prove the "equal gravitation of all substances." Since the resistance of the air to pendulums of different bulk and shape varied, it was necessary to reduce this condition to a constant factor before the single force of gravitation could be observed. The desired end was accomplished by the construction of hollow pendulums of equal boxes of wood and of iden-

1 Westaway, F. W., "Scientific Method," 1912, pp. 196–197.
2 Bosanquet, "Logic," Vol. II., pp. 144–145.
3 Westaway, *op. cit.*
4 Jevons, S., "Principles of Science," p. 423.

tical outward size and shape, hung by equal threads, with centers of oscillation at equal distances from the points of suspension. When these wooden pendulums were filled with equal weights of different substances and vibrated with equal velocity, any subsequent inequality in observed vibration of two pendulums must arise from the only condition which was different, namely, the chemical composition of the substances in the pendulums. Since no inequality was observed, it was concluded that the chemical composition of substances had no appreciable influence upon the force of gravitation.[5]

The botanist endeavors to discover the effects of light upon plant growth and resorts to the experimental method. A glass bell jar is placed over a plant and the growth compared with a plant in a shaded bell jar and another plant without a bell jar. But since the sun heats up the bell jars and the resultant warmth affects growth, it is necessary to shield the jars from the direct rays of the sun. In this way it is possible to exert a considerable degree of control over certain conditions which affect growth.

Experimental psychology began in 1840 with the work of E. H. Weber in sensation. Since then the experimental method has been applied to measuring the will, emotion, desire, feeling, memory, reasoning, attention, association and perception, with notable results.[6]

Sensations are mental processes easily controlled because they are connected with physical stimuli such as light, sound, odor and temperature, which can be readily governed. Taste, for example, is influenced by smell, temperature and touch. Each of these three factors may be controlled. Smell may be practically eliminated by plugging the nostrils with cotton. Temperature and touch may be kept constant by reducing all taste stimuli to liquid form and by maintaining liquids at a constant neutral temperature.[7] In this way the usual varieties of tastes have been reduced to four elementary forms, sweet, bitter, sour and salt. Indeed, when dealing with sensation the "essence of the experiment has consisted in controlling the physical stimuli which produce sensations, and then observing what alterations appear in the field of consciousness."[8]

Experiments in associational reaction have led to interesting results and practical consequences. Words are exhibited through a slit in a screen, and the subject is asked to state as promptly as he can the idea called to mind by the word. The reaction time is measured and recorded. Many tests of this sort determine the fundamental bias of the subject in favor of certain types of association; for example, simple concrete associations or imaginary and romantic combinations. The prin-

5 "Principia," III., vi; and Jevons, *op. cit.*, pp. 443–444.

6 Angell, J. R., "Chapters from Modern Psychology," 1912, Ch. III.

7 *Ibid.*, p. 84.

8 *Ibid.*, p. 90.

ciple is used more or less successfully in criminal procedure. Alienists and specialists in nervous disorders have had considerable success in using this experimental method to elicit information that is ordinarily repressed by the patient.

One of the most promising fields in which the experimental psychologist is working is the field of animal experimentation. The principle of evolution has established the physical continuity of animal and human life, animal experimentation has furnished evidence for the continuity of mental activity. Experimental psychology has demonstrated the important principle that the learning process in animals is by the trial and error method. All children and most human adults still rely on this fundamental process of mental activity. Shy animals as well as tamed ones have been experimented upon by ingenious methods devised by Professors J. B. Watson, E. L. Thorndike and F. P. Porter. These experiments have shown that animals can learn a highly complex reaction in as few trials as human beings and will remember for weeks at a time.

May not a method which has given such brilliant results in a field so closely allied to social science be successfully applied in sociology? It is the purpose of this paper to briefly outline the difficulty and promise of the experimental method for sociology.

Natural Experiments

Comte conceived of pathological cases as indirect social experiments. Whenever the regular course of a phenomenon is interfered with in any determinate manner, true experimentation takes place, and hence according to this interpretation of experimentation it is not important to have a conscious agent to effect the change. While it may be stated at once that Comte's notion of experimentation in the realm of living things was based upon the limited biological knowledge of his time, his concept of social experiments caused by the action of natural forces upon society has been of considerable suggestiveness for sociology. Under certain natural circumstances physical factors at the basis of social life have been limited, held constant, or the ordinary restraining factors have been removed so that the sociologist need only observe the effects.

Such a natural experiment exists in the Arctic Circle where the Eskimo live an isolated life under conditions of extreme simplicity. Here nature has withdrawn her usual variety of resources in flora and fauna, she has produced a pretty constant color scheme (or rather absence of color), controlled her temperature scale in such a fashion that variation in flora and fauna is repressed, and accomplished the maximum degree of isolation from the rest of mankind. Under these circumstances the struggle for existence is severely simple and the in-

habitants have evolved a remarkable system of adapted ways. The Eskimo, in the course of adapting their architectural methods to the only material at hand—snow—have developed the dome, a most unusual form among primitive peoples. Civilized man cannot better this snow Igloo of the Eskimo and finds it absolutely necessary to adopt other Eskimo ways in the Arctic region.[9] Other adaptations appear in the form of bone snow spectacles, bone bows and skiffs made of skins. In social life adaptations are seen in the absence of commercialism (due to isolation and lack of surplus), the elementary organization of property, the institution of polygamy (due to the high male death-rate), and the custom of patricide (due to scarcity of food). Here the sociologist may observe the effects upon social life of the elimination of many physical conditions considered fundamental in temperate climes.

Nature has performed an interesting experiment in the effects of isolation upon a people of much higher cultural stage. In the southern Appalachian mountains live over a million people who are the direct descendants of the colonial population of America. Here in these isolated valleys remote from the swarming centers of population, they have clung fast to the colonial culture with its spinning wheel and cumbersome hand loom. New ideas, modern inventions, contemporary science have come to revolutionize the life of the rest of the nation, while these quiet folk, serene in their simplicity, have been oblivious to all the rush and worry of new problems. President Frost, of Berea College, calls them "our contemporary ancestors of the South," and they do indeed reproduce the life of colonial times, constituting a natural experiment in the effects of isolation.

Professor Ross has given us a most interesting picture of China.[10] Here is another great natural experiment, but of another type. A strict family tradition has operated to maintain a static standard of living and offset the usual restrictions on the birth-rate, so that the population multiplies without let or hindrance. The result is seen in a striking example of Malthus's law of population. A positive effect is produced in the survival of a stock unusually resistant to disease. Here is a case in which most of the civilized interferences with the principle of natural selection are non-existent, and a rare opportunity is thus afforded to observe the operation of natural selection upon human subjects on a large scale.

Sociologists are only now becoming aware of the great significance of such "natural experiments" for the development of sociological principle. More of such careful observational studies as Nansen's "Eskimo Life," Ross's "Changing Chinese," and Mrs. Gerard's "The Land Beyond the Forest," to mention a few, are needed to fill in the sterile places of sociological theory with scientific data.

9 Nansen, "Eskimo Life."

10 "The Changing Chinese."

Experimentation upon Human Beings

But the sociologist can not rely on natural experiments alone to test his hypotheses. Such experiments are infrequent, they are not easy to recognize, are difficult to observe properly and will probably become more and more infrequent as time goes on, because of the standardizing effects of the spread of a more homogeneous culture over the world.

Have direct experiments ever been performed on groups of human beings by human beings? Have certain circumstances of social life ever been controlled or limited by conscious human interference? These questions have both a historical and a contemporary answer.

It may be stated as a truism that just so soon as the sociologist passes from the method of passive observation to active interference with the determining conditions of a social problem, he begins to encounter a stiffening resistance. The social reformer meets objections and obstacles at every step. All sorts of opposition are met by advocates of minimum wage bills, eugenic marriage laws, compulsory vaccination and child labor bills. The people believe that serious questions of individual rights, personal freedom and moral responsibility are involved. It is felt that, while the subject of experiment in physical science is inert and insensitive matter, in the social field the experimenter is dealing with exceedingly complex units capable of great individual suffering if the experiment should go wrong. There is a popular disposition to withhold or question the sanction for an act which puts in the hands of one person, or of a group, an apparently arbitrary control over the welfare and destiny of other assumedly equal human beings. Ideals of individual freedom and the sanctity of human life have been won after generations of struggle, and are regarded as too precious a heritage to abrogate in instances where the outcome is doubtful. The parent who experimented upon his children by limiting their food, strangely clothing them, or keeping them from school and intercourse with other human beings would soon be investigated and perhaps brought to court by the agent of the Society for the Prevention of Cruelty to Children. Certain acts although practised in a spirit of scientific experimentation are nevertheless considered criminal and their authors prosecuted by agencies which seek to preserve social welfare. One may experiment upon plants or insects without encountering moral objections, but just so soon as human life is experimented upon, society reacts unfavorably, either through its unorganized method of public opinion or through its more systematized agencies.

The line between permissible and forbidden subjects of experimentation is not sharply drawn. Experimentation, even for worthy scientific ends, when it affects the lives of higher animals is censured. In fact, there is now systematic opposition in the form of an organization of anti-vivisectionists. Yet the experimental method has nowhere

made more positive contributions to human welfare than in the field of live animal experimentation. The death rate from diphtheria has been reduced by the use of antitoxin from 80 per 100,000 in 1895, to 17 per 100,000 in 1907. Careful experimentation upon animals has given us the anti-meningitis serum which has reduced child mortality from this distressing disease over 50 per cent. Inoculation of children against tuberculosis is now possible because of experiments upon rabbits and guinea pigs. Experimentation upon dogs has given us the beneficent thyroid treatment for cretinism in children. Inoculation against malaria and bone grafting have been made possible by animal experimentation.[11] No harm has been done to social ideals and precious human life has been saved.

Yet in spite of this splendid array of worthy achievements which have reduced the pitiful suffering of innocent little children, there are still undiscriminating individuals who see in all animal experimentation a great moral menace. Such has been the mistaken zeal of these persons in the belief that their efforts are protecting our moral standards, that legitimate and beneficent researches of medical scientists have been hampered.

But where draw the line between experiments on living things and experiments upon human beings? Certainly these cases of animal experimentation are on the border line of moral standards. They form very illuminating illustrations of sincere differences of opinion as to where the end may and may not justify the means. Cases of the "poison squad" method of the military scientists or of other instances in which human individuals voluntarily renounce certain rights and freely submit to experimentation, would seem to grade off into this intermediate region where in connection with live animal experimentation the usual moral standards of the sanctity of life are observed to be border line and uncertain. As a matter of fact, there seems to be a regular evolutionary series of stages in the development of the sanction for experimentation. These stages are related to the character of the subject. The sanction for experimentation on inanimate matter and on plant life is within the personal choice of the scientist, no one questions his right; but just so soon as animal experimentation is reached, particularly in the case of higher animals capable of considerable suffering, the sanction of personal choice is regarded by many people as inadequate; and when human life is reached all people demand that a higher sanction for the act than personal will be obtained.

When individuals freely renounce certain rights and for the benefit of humanity submit to experimentation, society does not feel serious concern and may even recognize their self-sacrifice and heroism. The

[11] Chapin, H. D., "What Animal Experimentation Has Done for Children," *Popular Science Monthly*, Jan., 1915, pp. 55–62.

state alone, of human agencies, seems to possess by common consent the social sanction for mandatory interference with the normal lives of persons. Unless the individual voluntarily renounces his personal rights, none but the state may morally and legally take them from him. Society is the only official sociological experimenter. In the past, the sovereign power over human life wielded by the state has more often been exercised by an aristocratic or plutocratic minority than voluntarily and legally delegated by the people to their chosen representatives or executives. History is replete with illustrations of this fact. Tyrannical governments have experimented endlessly and thoughtlessly with the lives and welfare of the people. It is only in recent times that a democratic organization of governments has permitted the people to control legislative experiments upon human life and social welfare.

THE UTOPIAN COMMUNITY EXPERIMENTS

But before considering those social experiments sanctioned and attempted by the state, and always characterized by a certain amount of constraint, it will be well to examine a few cases of local community experimentation in which the elements are simple and the results positive.

The associationists of the early nineteenth century, Owen and Fourier, advocated the establishment of communities organized on a more ideal basis than the society of the time and promulgated broad humanitarian plans for the regeneration of mankind.

Robert Owen was a practical and successful manufacturer and his cotton mills at New Lanark, Scotland, were models of the time for all employers who sought the welfare of their operatives as well as efficient business organization. Owen's unquestioned achievements at New Lanark brought him a world-wide reputation and convinced him of the practicability of putting ideals of social reform into every-day life. He firmly believed that "man's character is formed for him by the circumstances that surround him, that he is not a fit subject for praise or blame, and that any general character, good or bad, may be given to the world by applying means which are to a great extent under the control of human governments."[12] Assuming then that, at bottom, human nature is fundamentally good, it only remained to eliminate the restraining bonds and the demoralizing influences of existing society to attain harmonious social relations in an ideal community. Owen thought that the evils of the capitalistic system were due to the restraining effects of private property, orthodox religion, and the existing institution of marriage.[13] The remedy for present evils was, therefore, the abolition of these three institutions.

[12] Robert Dale Owen, *Atlantic Monthly*, 1873.

[13] Lockwood, G. B., "The New Harmony Communities," 1902, p. 63.

It was with full confidence that Owen embarked upon the experiment of putting into practise these social ideals. Early in 1825 he purchased 30,000 acres of fertile land of the Rappite Community at Harmony, Indiana, and rechristened the place New Harmony. There were 3,000 acres of land already under cultivation, fine orchards, eighteen acres of full-bearing vines, a regularly laid-out town of 160 houses with streets at right angles to one another, and a public square with large brick buildings.[14]

Founded on the principles of common ownership of property, an unorthodox religion and a simple marriage relation, as Owen understood them, the New Harmony community of 900 souls started on what was to be an epoch-making experiment in the reconstruction of society. Back of the rich natural endowment stood Owen with his generous fortune, ready to assist. But although well supplied with material things and supported by the unfaltering enthusiasm of Owen, the community came to a disastrous end in 1827.[15] The seamy side of human nature appears to have cropped out from the beginning. The community was a very heterogeneous group of persons from many states of the Union. Petty jealousies and quarrels were the constant order of events. One observer writes:

> The people in the town continued strangers to each other, in spite of all their meetings, their balls, their frequent occasions of congregating in the hall, and all their pretence of cooperation. From the first time I set foot within this little town of one half mile square, I think there is not one within the range of my observations during my traveling in other towns of the United States, where the same number of persons, living together within such a compass for so many months, and daily and hourly passing and repassing each other, were so perfectly strangers, and void of all personal intimacy with each other's feelings, views, situations and, very generally, names.[16]

Witness to this state of affairs is borne by the local newspaper, the *Gazette*, for at one time it makes reference to the fact that, "the most eccentric and violent characters" had left the community. Again it admits that

> the principal thing to be contended with is the character formed by a new country. Families have been here collected without any relation to each other's views and peculiarities. Many of these persons, after their arrival, have been deprived of more or less of their property, and a general system of trading speculation exists among them, each one trying to get the best of the other. Confidence can not, therefore, exist among them, and there is an unreasonable spirit of suspicion prevalent. Inexperience in community enterprises is another great obstacle, and education alone can overcome these difficulties.[17]

[14] Macdonald's MSS Collection, quoted by Hinds, W. A., "American Communities," revised ed., 1902, pp. 130–131.

[15] Hinds, *op. cit.*, p. 134.

[16] Lockwood, *op. cit.*, p. 165.

[17] Quoted by Lockwood, pp. 168–170.

In the New Harmony *Gazette* of March 28, 1827, the failure of the experiment is acknowledged in these words:

Our own opinion is that Robert Owen ascribed too little influence to early anti-social circumstances that had surrounded many of the quickly collected inhabitants of New Harmony before their arrival here, and too much to the circumstances which experience might enable them to create around themselves in the future. He sought to abridge the period of human suffering by an immediate and decisive step, and the plan was boldly conceived; the failure would only afford proof that the conception in this particular case was not as practical as it was benevolent, in as much as the mass of the individuals at New Harmony were not prepared for so advanced a measure.

In an address at New Harmony Hall on April 13, 1828, Owen said, speaking of the failure of his experiment:

This proves that families trained in the individual system, have not acquired those moral characteristics of forebearance and charity necessary for confidence and harmony; and communities, to be successful, must consist of persons devoid of prejudice, and possessed of moral feelings in unison with the laws of human nature.[18]

Other observers concluded that a communistic system such as Owen had devised could not exist unless in a place utterly removed from contact with the world or save with the help of some powerful religious conviction.[19]

To the extent in which the institutions of private property, religion, and marriage were eliminated or controlled as constant conditions in the life of New Harmony, we have here a real social experiment. On the assumption that these three fundamental human institutions were actually eliminated or reduced to constant elements, we have experimental proof of the instability of society without them. But granting all this, general conclusions are invalidated by the fact of heterogeneity of population a variable and uncontrolled element in the experiment. The deplorable absence of like-mindedness in New Harmony vitiates any inference as to the ultimate effect upon society of the elimination of these fundamental institutions, unless it be the conclusion that without the unifying discipline of these factors a heterogeneous aggregate of people can not live together in peace and harmony. But this is not a new principle of sociological knowledge.

Charles Fourier (1772–1837), the contemporary of Robert Owen, was also a keen critic of the existing industrial system and placed great stress on the principle of association as a remedy for social injustice. Fourier advocated the reconstruction of society on the lines of small self-supporting cooperative communities called phalanxes. Each association was to be composed of some 1,800 members who worked in harmony with one another for the benefit of the community. Every

[18] Lockwood, *op. cit.*, p. 214.
[19] Hinds, *op. cit.*, p. 135.

worker was to take up a different task at the end of two hours, in order that there might be the spice of variety. Labor was to be paid for in order of the necessity, usefulness and agreeableness of the task. He believed that the proposed reorganization of society would permit all who started productive work at eighteen to retire for a life of leisure at twenty-eight.

Fourier's ideas were accepted with enthusiasm by the inhabitants of Brook Farm in 1844. This interesting community was organized in 1841 by a group of New England idealists—orators, philosophers, poets and transcendentalists. The Rev. George Ripley, founder of the Brook Farm society, proposed "to establish the external relations of life on the basis of wisdom and purity; to apply the principles of justice and love to our social organization in accordance with the laws of Divine Providence; to substitute a system of brotherly cooperation for one of selfish competition; to institute an attractive, efficient and productive system of industry; to diminish the desire of excessive accumulation by making the acquisition of individual property subservient to upright and disinterested uses; and to guarantee to each other forever the means of physical support and spiritual progress."[20]

The association was founded on a joint-stock proprietorship with capital shares of $100 each and a guaranty of five per cent. per annum interest return. Although communism in the basic property of the community was not practised, there were common industries, equal wages, a common guaranty of support to all members, their children and family dependents, and housing, food, clothing, and other necessities without charge exceeding a certain amount fixed annually by the members. Education and the use of the library were free to all members.[21]

> The aim was to secure as many hours as was practicable from the necessary toil of providing for the wants of the body, that there might be more leisure to provide for the deeper wants of the soul.[22]

The testimony of observers seems to be agreed that this association of idealists lived in harmonious relations. It is said that the survivors of Brook Farm long cherished the memory of the few years spent in associative life as the happiest and most profitable they had known.[23]

The acceptance of Fourierism in 1844 appears to have come at a juncture in the history of Brook Farm when financial difficulties made the future existence of the experiment problematical. A new constitution was adopted and the society was incorporated by the state legislature. A rather complicated system of government was drawn up and the industrial organization of the community was worked out with

20 Preamble to Articles of Agreement and Association, signed by the Brook Farmers.

21 Hinds, *op. cit.*, pp. 231–232.

22 Frothingham's account of Brook Farm, quoted by Hinds.

23 Hinds, *op. cit.*, p. 231.

typical Fourieristic detail—farming series, mechanical series, domestic series, and so on, each series being subdivided into many groups. For a time there appears to have been a profitable renewal of industrial activity, but the financial problem was still unsettled. Finally, a great disaster, the destruction by fire of the large $7,000 unitary building, had such a depressing effect upon the members that one by one they lost heart and departed.[24] The experiment was brought to a close in 1847 after six years of harmonious community life.

In many respects the Brook Farm experiment was a complete contrast to the New Harmony experiment. In the one, harmonious relations were enjoyed for six years by a small group of like-minded and highly cultured people who, however, failed to make their communism a financial success; in the other, friction and lack of harmony existed from the first among the heterogeneous aggregate, and although the financial backing was adequate and generous, the experiment came to a disastrous end in two years. It is difficult to draw any general conclusions from the Brook Farm experiment which will be sufficiently definite to have sociological value. The one outstanding fact, however, seems to be that like-mindedness is sometimes a more fundamental condition of community survival than material endowment. But here again, local experimentation has established no new sociological principle.

The most successful experiment in Fourieristic principles was the North American Phalanx organized August 12, 1843, near Red Bank, Monmouth County, New Jersey, and continuing with considerable prosperity for thirteen years. The New York *Tribune* described the community in 1854 as located on a domain of 673 acres of land, equipped with steam flour and saw-mills, a mansion house, packing house, carpenter's shops and blacksmith's shops. Near the mansion house was a nursery where the children were taken care of while their mothers worked. The inhabitants numbered about one hundred persons. Labor was divided into various departments occupied with fruit drying, the bottling of fruit, the cultivation of potatoes, tomatoes, turnips, melons, cucumbers and garden seeds, the manufacture of wheat, rye, and buckwheat flour, corn meal, samp and hominy. The labor of each person was credited by the hour and charged with board, lodging and other things received from the association. The balance due for excess labor value was paid in cash.

This community weathered many of the preliminary dangers which had broken up other experiments of a similar nature. There were personal difficulties and two parties contended for authority, yet neither of these factors was directly responsible for the final dissolution of the association. As late as August, 1855, a visitor to the phalanx testified

[24] *Ibid.*, pp. 233–239.

to the still prevailing spirit of contentment. Yet shortly after this favorable report a difference of opinion arose concerning the location of a new mill and when the question was put to vote the majority was found to be in favor of dissolving the community.[25]

The causes of the dissolution seem to have been various: among the chief of them was lack of educational facilities, a secession of some of the members, the burning of the mill, and dissatisfaction about the return paid for labor. It appears that there was not sufficient distinction between labor of brain and muscle. The president received only ten cents a day more than a common laborer. It is significant that wage troubles were such an important factor in causing dissatisfaction when it is recalled that the community was established for the very purpose of destroying wealth and income distinctions. Hinds makes this comment upon the fact:

> But all this talk about wage troubles, to my mind, only proves that the great objects which originally drew the members together had lost their first power over them, and that lower and more material considerations were becoming dominant in their minds and hearts.[26]

This community experiment appears to have been well endowed materially and not to have suffered much from internal dissension. What was the cause of its failure? It would seem from the foregoing enumeration of causes that the most potent factor was lack of isolation from the disturbing influences of outside society. It should be remembered that all of these community experiments[27] were carried on in a social medium, and that the guiding motives of life in surrounding society, the prejudices, the customs, the laws, the forces and various principles of elemental human nature, were uneliminated and troublesome influences. Scientific experimentation under such limited conditions of control was impossible. (It was like attempting to conduct a chemical experiment in a bowl of molasses.) Consequently the conclusions from such experiments must be qualified by the unsatisfactory control of the experiment.

The condition of isolation so fundamental for successful social experimentation was never actually realized in the utopian community experiments, and it is an open question whether this prime condition can ever be enforced in social experimentation by active human interference. But sovereign states have, however, experimented upon the people without the aid of this important condition. Since the subject is obviously unlimited from the historical point of view, it will be well to confine our analysis to a few typical contemporary cases.

(To be Continued)

25 Hinds, *op. cit.*, pp. 243, 247.

26 P. 248.

27 There were in all twenty-nine Fourieristic communities in the United States with memberships of from 20 to 420 persons, with lands of from 150 to 30,000 acres, and lasting for from six months to thirteen years each. Hinds, p. 224.

THE LUCK ELEMENT[1]

By A. G. KELLER

NEW HAVEN, CONN.

THE prime necessity of human life on earth, as of all life, is adaptation to life-conditions. Human beings have found themselves confronted by various sets of these conditions, and have reacted upon them in a characteristic way; but whereas plants and animals have been forced to structural adjustments, on the basis of which they are classified into varieties, species and genera, men have performed mental and social adaptations, nearly as automatic at first as those of other organic beings, on the basis of which they are classified into grades of civilization. These life-conditions include those of the natural environment, such as climate, flora and fauna; those of the social environment of fellow-men; and those of the environment of ghosts and spirits. Adjustment to these several sets of conditions is through common modes of conduct, or folkways, out of which gradually crystallize the institutions of society.

A condition of a less material order which the most primitive of men were obliged to recognize as a part of life on earth, and to which they had to adapt themselves, was what we call chance or luck. Efforts and results are found not to be strictly in proportion, though experience shows a correlation between them upon which the race, in actual living, has had to depend. The same effort in hunting, put forth upon two separate occasions, has resulted now in plenty, easily obtained, and again in destitution and fatigue. Variation from the expected is always taking place, in all ages and stages. The liner strikes the derelict, drifting awash; the tire picks up a nail; the ivories kiss just as a hard shot and an excellent position are about to be attained; the baseball strikes an uneven spot and jumps over the fielder's head—and disappointed men groan over "bad luck" and "jinxes." The liner shaves the derelict; the nail is found to have little more than scratched the tire; a kiss results in making a shot and attaining a position uncontemplated; the safe hit is deflected into the fielder's hands—and then the favored men exult over "good luck" and "horse-shoes."

[1] This conception of the luck element in its relation to the evolution of religious beliefs and practises is based upon an analysis developed, mainly in lectures, by Professor Sumner. It has seemed to many of us both profound and suggestive, and we think it should be more widely known, and known as his. It is somewhat elaborated here; but the basic idea is not the writer's.

Luck plays a great part in any one's life. It may make or ruin. Upon the primitive stage it is the more significant because men live, so to speak, on the edge of existence, and it does not take much mischance to push them over. What wonder, therefore, that this element in life has occupied men's thoughts through the ages? They have loved it and feared it; and they have played with it as with no other interest. "Interest" is the word for their attitude toward it. The passion for getting something for nothing and the fear of getting nothing for something have always fascinated the human mind.

It would be entirely irregular if the presence of an element like this, among the life-conditions, had not evoked, in the course of social evolution, an important set of social adaptations. Reaction upon the physical environment has resulted in the industrial organization of society. Relations with the social environment have worked out into domestic and political institutions. The biological fact that *homo* is bisexual has led to a long series of adaptations that would not have appeared had *homo* been an unisexual organism. What human institutions correspond to the presence in the field of the element of chance or luck?

But, first, let us examine the element itself. Modern science, of course, recognizes no such thing as chance, in the sense of a result without a sufficient cause. It believes that nothing ever "just happened." The most "fortuitous" event can be explained if there is knowledge enough. The liner reached a certain point of latitude and longitude, at a certain instant, as the result of numerous contributing causes—steam-pressure, head-winds, gales, strikes, temperament of captain, and so on—the action of any one of which could have been predicted if knowledge had been sufficient. Similarly with the derelict. The collision was, therefore, in the natural order of things. There was no miracle or magic about it. The nail lay in such a position that it was bound to make a puncture or merely to scratch the tire. The billiard-balls were sure to kiss at the exact spot where they did kiss, being struck as they were. The inequality in the ground being such as it was, and the baseball coming as it did, the result could be indefinitely repeated if the conditions could be duplicated. It is all a question of knowing and foreseeing. To omniscience there could be no "luck"; to advancing knowledge there is less luck; and, as one set of phenomena after another is included within the range of rational explanation, the conviction has grown that law obtains throughout the universe, to the total exclusion of chance.

Luck, then, is a name for that which is inexplicable on our stage of knowledge, or in view of our unwillingness to take the trouble to get or apply that knowledge. It is what we are too ignorant or too unenterprising to figure out. Omitting the latter consideration as representing the entrance of the personal equation, the importance assigned to

luck varies inversely with the amount of knowledge. This means, however, since the knowable is immeasurably vast, that the luck element will always be an immense factor in human destiny.

Perhaps it is superfluous to point out that we currently recognize this relation of chance and knowledge. If a man "takes no chance" it means that he is informing himself to the utmost—indeed, he may even be fully informed and "betting on a sure thing." And after listening awhile to a person whining over his bad luck, are we not often exasperated into a partial personal investigation of his case, with the result that we find "not so much bad luck as bad management"? Again, when the small boy lays his finger upon the hot stove, we comfort him and say "Hard luck, old chap!" It was that, to him—he "didn't know any better." And, in our condolence, we put ourselves in his place. If a grown man should do the same thing and howl over his experience, the answer might be: "Serves you right! You knew better than to do that—or, anyhow, you ought to have known better."

Now the savage is like the child. His knowledge, beyond the restricted sphere of immediate experience, is small. The explicable, to him, is an exceedingly limited range; and the range of the inexplicable, the unreckonable, is correspondingly wide. Add to this the fact that ill luck, even a little of it, is a vastly more serious matter to him than to civilized man, and the significance to his destiny of the luck element—the "aleatory element" of Professor Sumner—is indefinitely enhanced. It forms for him, as the facts show, one of the major conditions of life on earth; and his adaptation to it, as he sees it, works out into an important set of social structures.

Nowadays civilized man has at hand an adaptation to the aleatory element which is the fine fruit of some of primitive man's primeval gropings toward safety in the face of mischance, viz., insurance. Insurance, in itself, does not lessen the losses involved, but it distributes them so they can more easily be borne. It reduces a variable of shattering loss to a constant of endurable loss. It is always loss, be it noted—loss, submitted to in order to avoid utter calamity. In insurance-operations recourse is had to the laws of chance and actuaries figure out about what amount of mischance can be reckoned on. Then this is distributed in the form of premiums paid on policies. Insurance is a grand device, and its roots go farther back than one would think, offhand. Mankind on earth has always had an eye to the avoidance of ill luck, and in all ages has tried somehow to insure himself—to take out a "policy" of some sort. His methods of so doing were often rude and mistaken, but they were susceptible of replacement and rectification. Only by some such device was existence possible, in the presence of the menacing inexplicable.

But it may be objected that there is just as much good luck as ill luck, and the optimist will doubtless remark that all is for the best in this best of worlds. There is room for a difference of opinion here, no doubt; but the fact is that the tendency of human nature is to take good luck to be normal and as the matter of course, and to confine attention pretty largely to the ill fortune. Perfect health is not normal, yet we go on the theory that it is, and grumble at illness as a misfortune. Age brings on a series of discomforts; they are perfectly normal; but we still refuse to consider the good days as good fortune, and complain about the bad ones. That man was a great philosopher who kept a diary to which he looked back at times of discomfort, always finding some occasion when he was worse off. We do not take much pleasure in past joys when we are being plagued, but subscribe rather to the sentiment about sorrow's crown of sorrows being the remembrance of happier things.

But engrossment in the present is the rule among peoples whose representative faculties are relatively weak. Also, among the primitive folk, as has been intimated, ill luck is more important than good luck because, while the latter may be highly desirable, the former is supremely undesirable. It may mean present death; or a disablement, readily curable by us, but permanent and in the highest degree dangerous on a low stage of civilization; or some hideous disease. The experience of good luck never relieves people on that stage of the present fear of ill—indeed, a run of good fortune frightens them to the last degree, for it is a sure harbinger of calamity. Witness Polycrates. It is necessary to walk very softly when things go well, with an eye always cocked toward the perennial menace of ill. And if we recall the manifold dangers surrounding human life, before the barrier of civilization was built up to afford it some protection, we shall not be surprised at the prevalence of interest in avoiding ill as over against interest in attaining good. It is necessary to set ourselves in the situation of primitive man to realize this; but any one can help himself to do that if he will realize that the savage was really involved in a struggle for existence, whereas none of us are. We struggle for a standard of living; and if we lose out utterly, still existence is assured to us by the society in which we live. But our far-away ancestors, and their present-day representatives, the nature-peoples, lived and live in a direct relation to physical environment, one full of perils of a vital order. They were and are victims of a vivid fear of calamity; the "free and noble savage" was a philosopher's phantasm.

With the aleatory element, especially in its negative phase of ill fortune, filling the perspective as an enduring and real menace—forming one of the major conditions of life—the primitive man at once sensed the discomfort that enforces adaptation. His attitude could

not be one of indifference, nor could his mind develop or harbor the more evolved conceptions that characterize a higher civilization. He could not conceive of the refined faith of the civilized man, any more than of the resignation of the stoic or the more enlightened resignation of the agnostic. Yet he must do something to avoid ill; and for that he must have some explanation of the inexplicable. It was not that he was at all the victim of intellectual curiosity. If this matter had not touched vitally upon his most vital interests, he would never have sensed the need of explanations. There had to be something accounting for the aleatory element, precisely in order to deal with it. He was not after any pure science at all, but the question was simply: What to do? How to insure against ill, that always threatened, but was not to be accounted for upon any basis of actual experience?

This was the issue that lay before the primitive folk in the face of this peculiar and inevitable life-condition. If anybody imagines that they attacked the issue and solved it by a conscious rational procedure, he has yet a great deal to learn about the early stages of society's evolution. Primitive people could not even have formulated the issue, let alone applying ratiocination to it. They felt it in a dull sort of way, and squirmed and fumbled about to dodge the pain or secure some alleviation. How, automatically and un-rationally, to get hold of some explanation of the inexplicable—that seems to be a problem indeed for childlike minds with but slight and unreliable equipment of matter and method.

In the primitive mental outfit, however, there existed a set of beliefs competent to account for all mysteries. Starting with a belief in the double or soul, practically all primitive people have developed the notion of the ghost and spirit, an evolution expounded by Spencer and others. And in this animism and daimonism there existed an entirely sufficient explanation of any and all the phenomena of the aleatory element. I do not need to go into the details of this matter. It is enough to say that the daimons were all-powerful, irresistible by unaided man, capable of inflicting "strange agonies" of all sorts, and, for the most part (corresponding to the aforesaid preoccupation with the negative side of the luck-element) they were maleficent. Whether ill-intentioned or not, their presence was productive of ill; the ghost of a dead mother, embracing her child, would cause its death or otherwise afflict it. There was, in short, no woe or calamity of man that could not be referred to the spirits. The spirit environment formed a complete and ready explanation for any and every phase of the aleatory element.

It is not asserted that the recognition, conscious or unconscious, of the element of chance summoned into being the idea of the spirit environment. That conception arose from other sources altogether.

But it was there, and it explained the otherwise inexplicable. The two conceptions dovetailed together, and out of this situation arose that important complex of social institutions of primitive times which we know as primitive religion.

The two conceptions still cling together. Inexplicable or unforeseeable calamities are still designated, generalizing, as "acts of God" or "acts of Providence." What men can understand and provide against they do not so designate. The range of the aleatory element has been much restricted by the growth of knowledge—we do not need the supernatural explanation of fossils, or thunder, or the plague any more, but explain by "lower" causes where they can be enlisted.

However the range of the aleatory element, as the inexplicable, is and always has been infinite; and so the inroads of knowledge and science amount in the end to subtracting something from infinity. The remainder is still infinity. But it satisfies the mind and clarifies the course of social evolution to note this one among the several cases of adaptation to life-conditions exhibited by the race. If there had been no luck element, there might have been a very different sort of animism, daimonism, and religion. As it actually has been, the former was a condition of life on earth to which men automatically adjusted themselves by recourse to the development of the religious institutions.

MENTAL AND MUSCULAR WORK

By Dr. JAMES FREDERICK ROGERS

NEW HAVEN, CONN.

THOSE who have had the opportunity of observing the results of muscular and mental effort have often noted a coincidence between the ability of a pupil to perform gymnastic feats and his proficiency in theoretical studies; and the generalization has been made that there is an intimate relationship between muscular and mental power. For a study of this relationship the power of grip ("strength of forearm" as it has been called) as recorded by the spring dynamometer, of seventy-five young women of one class of the New Haven Normal School of Gymnastics, was compared with the marks received (average of two examinations) in the study of human anatomy. The slight similarity between the results of these tests for muscular and mental effort was so apparent, when the marks were down on paper, that a comparison by groups alone seemed worth while. The grouping was made according as the pupils received a mark of 90 or more, 80 to 89, 70 to 79, and 69 or less in anatomy, the largest number of the class (thirty-eight) falling into the third group.

The average of the strength tests for each group was: for the 90 or more, 37 kg.; for the 80 to 89, 35 kg.; for the 70 to 79, 31 kg.; and for those below 70, 35.5 kg. The lowest strength record, 22 kg., was made by a pupil who received an anatomy mark of 75. The greatest display of strength, 49 kg., was exhibited by two members of the class, one of whom received an examination mark of 91 and the other 80. One of these with an anatomy mark of over 90 gave a strength test of only 30. The lowest strength test given by those who attained over 90 was 30 kg., and the same grip was the lowest exerted by those who did not reach above 69.

From such figures and such means of comparison, there is (on the strength plane represented by a grip of 22 kg. or more) evidently very slight connection between the results of mental and muscular effort. However, the markings for anatomy represent prolonged mental effort, while the display of muscular force upon a dynamometer does not indicate the possible power for continued muscular exertion. There might be a closer relationship between mental marks and tests for prolonged muscular work. As a simple measure of the endurance of the pupils they were asked to hold one arm in the abducted horizontal position as long as possible. The variation in the results of this test was far wider than that for the brief display of muscular force, and there was little correspondence between the strength and endurance tests of each indi-

vidual. One young lady who gripped with a force of 49 kg. held her arm out for only three minutes and 45 seconds, while another, whose grip was but 22, kept her arm raised for seventeen minutes.

Individually again there was no relation between muscular and mental endurance, if we can so speak, only one of those receiving a mark of over 90 showing muscular endurance of more than 10 minutes, while one who received 66 held her arm out for 95 minutes, and one who had a mark of 70 made an unfinished record of 121 minutes.

The wide variation in the powers of endurance as shown by this test are of much physiologic interest. Two of the tests were incomplete, owing to lack of time. One of these young women felt no fatigue at the end of an hour, nor the other at the end of two hours. A similar wide variation was shown in the tests made by Prof. Irving Fisher,[1] in which both arms were held horizontally, from a minimum of six to a maximum of two hundred minutes. In the latter tests, flesh-eaters attained an average record of only twenty-two minutes and there seemed to be some proof that the vegetarians in the contest had superior powers of endurance. All members of the group tested in the normal school were flesh-eaters, most of them ate at the same table, and all had received for months the same muscular training. These endurance tests were taken without class competition.

In addition to the above tests and comparison, a similar endurance test was taken of eighty-six freshmen boys in the high school, near the end of the school year. A rough average of the marks for the year in all mental branches was made, using the system of grading of the school. Those having an average of over 90 falling in grade A, between 75 and 90 in grade B, between 60 and 75 in grade C. The endurance test was taken in class and was limited to twenty minutes. While many would have held out longer, the general result would probably have been much the same. for the Class A pupils gave an average of 12⅓ minutes, the Class B 16 minutes plus, and Class C 13.9 minutes. The high-school boys did not therefore exhibit any more connection between mental and muscular powers than did the normal-school girls. Not even does the superior ambition which is presumed to impel to mental superiority seem to have any effect in adding to the prolongation of neuro-muscular effort of those of high scholarship.

From the results of such uncertain means of measurement the variability in powers of muscular exertion and especially of prolonged muscular work, are evidently as great as for mental effort, or, more accurately stated, the neuro-muscular quality of prolonged effort is as variable as the cerebral qualities involved in acquiring and expressing an orderly collection of facts on a given subject. The wideness in variation of the neuro-muscular quality among those who have for a

[1] "The Influence of Flesh-Eating on Endurance," Irving Fisher, Ph.D., *Yale Medical Journal*, March, 1907.

considerable time been subject to the same diet and the same gymnastic and athletic exercises shows that the quality is innate and subject to little modification by training. A like inherent power for grasping a subject must have been noted by all teachers of mental work and the discouragingly slight change in quality of such work brought about by the efforts of the teacher is also familiar.

While such a comparison of tests would seem to show that there is little connection between exercise of the mind in school work and the exercise of the muscles in strength and endurance tests, it does not follow that the results of mental work carried on through one's own initiative may not correspond more nearly with one's power of muscular endurance, nor does it signify that mental superiority, and that complex which we call health, have no intimate connection. As Emerson said, "For performance of great work it needs extraordinary health." "When nature goes to create a great man she puts a symmetry between the physical and intellectual powers." The man of genius certainly has, as a rule, been a man of most unusual bodily powers. Napoleon, up to the time he became emperor, knew no such thing as fatigue. He said of himself that he had "the constitution of an ox." Tolstoi, at the age of fifty-eight, walked 130 miles in three days without fatigue. Porson, the great Greek scholar, frequently walked 52 miles to his club. Walter Scott was a supremely healthy man who could walk thirty miles a day. Samuel Johnson, Goethe, Humboldt, Wordsworth, Tennyson, Browning, Brahms, Beethoven, Wesley, Beecher, Gibbon, Washington, Lincoln, are but a few examples of men of genius who showed great bodily powers. There are exceptions to the rule, though these were none the greater for being exceptional. Even geniuses of slight physique, such as DeQuincy and Charles Lamb, were tireless walkers, Poe was athletic before he was overcome by alcohol, and even Stevenson showed unusual muscular powers for so sickly a person. Doubtless walking would be a far better test of endurance than the mere extending of the arms. As for strength tests, we know that Franklin astonished his printer companions by carrying two forms of type to their one; that Tolstoi could lift a hundred and eighty pounds with one hand, and that Walter Scott as a young man "could lift a smith's anvil with one hand, by what is called the horn." Scott does not give the weight of the anvil, but the feat was evidently an extraordinary one. Lincoln, it is said, could lift three times as heavy a weight as any common man. None of these men (unless it was Tolstoi) underwent any systematic "physical training" and the muscular powers they exhibited were either inborn, or developed along with the extraordinary exercise of their mental machinery. We do not know what relationship the ideational bear to the motor regions of the brain, but the exercise of the former must bring to the latter a blood supply which they would not otherwise receive, and these batteries, from which muscular activities are originated, might be the larger and more powerful for such association.

Though the foregoing figures do not prove, they do not disprove that the combination of a superior showing in muscular strength or endurance with superior showing in mental effort makes (other things being equal) for the best prospect for future accomplishment. Chief among the "other things" are ambition and the incentive of material needs. Poverty, or the fear of poverty, is a better soil for genius than prosperous surroundings. Much of the world's choicest production, in art or literature, would never have existed had bread and butter been forthcoming without work.

The results of these tests are of more use in what they do not prove than in what they prove. They are suggestive especially of the complexity of the matter examined and the questionableness of the value of such tests of either muscular or mental effort. The successful application of the mental machinery to routine school work depends upon heredity and extra-educational conditions, the brain being, with the same perfection of bodily backing, easily set to work upon scholarly pursuits in the one case, while in another case these are as foreign as the weaving of silk to a threshing machine. The man of genius toils joyously where the average student works without interest as well as without fitness for his task. Even the man of genius, as Boileau, Rousseau or Goldsmith, has sometimes seemed a dunce in his work at school.

The great variation in the results of these tests of strength and endurance emphasizes the fact (well enough known but often overlooked) that these, like mental qualities, are inborn, are not to be created by any form of training, and that, given the opportunity, they will develop to near their maximum. Muscular or mental training furnishes only an aid to completest development and maintenance of these powers. In systematic gymnastic, manual, and other forms of physical training there is combined training of both muscular and mental faculty. Unless muscular exercise is overdone it helps to maintain health and so to keep the mental powers at their best. A DeQuincy may feel the need of a walk of at least fourteen miles a day. An Edwin Booth or a Lord Lyons may find himself as well off with a minimum of muscular effort. The remark of Emerson, after his experience in gardening for health (into which he was inveigled by the enthusiastic counsel of Thoreau), is significant. He wrote:

> If I judge from my own experience I should unsay all my fine things, I fear, concerning the manual labor of literary men. . . . To be sure he may work in the garden, but his stay there must be measured, not by the needs of the garden, but of the study.
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> When the terrestrial corn, beets, onions and tomatoes flourish, the celestial archetypes do not.[2]

[2] The writer is much indebted to Miss Nina A. Dudley, of the New Haven Normal School of Gymnastics, and to Mr. Rufus A. Spencer, of the New Haven High School, for directing the tests here described.

MILK, SANITARY AND OTHERWISE

By Dr. JOHN WADDELL

SCHOOL OF MINING, QUEEN'S UNIVERSITY, KINGSTON, ONT.

SEEING that for a length of time, extending from a number of days to a year or more, milk is the sole food of over two thousand species of animals among which are the mouse and the elephant, the porpoise and the whale, and also the bat and the flying squirrel, it is evident that it must play a very important part in the economy of nature.

Milk is sometimes called a perfect food and the milk of each species may be considered such for the young of the same species. It contains all the essentials of a food, namely, carbohydrates, fats, protein and mineral salts. Carbohydrates form a group of organic compounds, which include sugar, starch and cellulose, and are composed of carbon, of which the most common form is charcoal and of hydrogen and oxygen in the proportion in which they exist in water. Fats are also compounds of carbon, hydrogen and oxygen, but in different proportions and in a different state of combination from those found in the carbohydrates. The carbohydrates and fats burn in the body as wood or coal burns in a furnace. They are capable of supplying the heat of the body and the energy that is required for its activity but they can not build up new tissue nor repair waste. This is the function of protein, so called from the many forms in which it exists. The name is a general one for a number of more or less distinct substances which agree in having a complicated structure in which nitrogen is an essential element and in which sulphur and phosphorus frequently occur. Muscular fiber consists largely of protein, and as protein is the part of the food which supports growth it is absolutely necessary. If more protein is taken into the system than is necessary for the nutrition of the tissues, it may supply energy and heat, but, for the same amount of heating value, proteins are much more expensive than carbohydrates. Excess of protein, as well as excess of fats or carbohydrates, may be used to increase the fat of the body. Animals are fattened by heavy feeding in many cases. Protein is formed in lean meat and in the white of egg and is the essential though not the largest part of cheese.

The carbohydrate in milk is chiefly milk sugar, which is in many respects similar to cane sugar, but is not quite so sweet and is not fermentable by ordinary yeast to form alcohol.

The fat does not differ more from other fats than they do among

themselves, but it contains a small quantity of compounds which on decomposition give butyric and other acids, causing rancidity.

The proteins in milk are of two kinds, casein and albumin, and the milk of different species of animals differs more in the character of the proteins than of the other substances. Casein coagulates in the stomach by the action of rennin, albumin does not coagulate in this way. The relative quantities of these differ in different kinds of milk and the nearest to human milk in the character of the protein and indeed in all respects except the percentage of fat is that of asses. The milk of reindeer contains a large amount of fat, almost as much as the cream of ordinary cow's milk and it also contains a large amount of casein.

Though we are accustomed in this country to use only cow's milk, the milk of other animals, as is well known, is used in other lands. In Scandinavia and other northern regions reindeer's milk is a common article of diet, its fat content making it specially valuable there. Camel's milk is in favor in desert countries, mare's milk in Russia and Central Asia, while goat's milk is not only common in the hilly countries of Europe, but is sold on the streets of Paris. One of the picturesque sights of that city is a goatherd leading his flock through the streets and stopping to milk as from time to time a customer appears. In the Marais, a district not far from the Louvre, formerly an aristocratic quarter, but now a congested area of slums, a goatherd may frequently be seen sitting on the step of a door surmounted by the armorial bearings of some scion of the nobility, drawing from a goat the quarter litre of milk demanded by a ragged woman for her squalid child. Nor is goat's milk used in the poor quarters alone. Near the Bois de Boulogne, in the early morning hours one may be wakened by the sweet notes of the shepherd's pipe and may, if quick enough, catch sight of him as he jauntily leads his herd along for the benefit of this district also.

While the casein in milk is coagulated upon entrance into the stomach, that of different animals coagulates in different ways. One typical method is that of the cow, sheep, or goat, examples of ruminant animals. In these animals the casein coagulates to a solid mass, which remains for a considerable time in the stomach and is there largely digested. This prepares the stomach for the later digestion of hay and other material of a similar nature. The second typical method of coagulation is that found in the milk of the mare or ass, non-ruminant animals, whose digestion is mainly intestinal. This coagulation is gelatinous, and the material passes rapidly from the stomach to the intestines. The third form of coagulation is intermediate; flocculent masses being produced which though digested to a greater extent in the stomach than in the second case are not nearly so fully digested as in the first case. An example of this kind of flocculent coagulation is

afforded by human milk, which in this respect also more resembles that of the ass than that of the cow.

When we speak of milk without any specification we always mean cow's milk and it may be well to make a comparison between the average cow's milk and the average human milk. Of course, the great bulk is water, being a fraction over 87 per cent. in each case. In human milk the total solids are 12.6 per cent. and in cow's milk 12.8 per cent. In human milk the total protein is 2 per cent., two fifths being casein and three fifths albumin; cow's milk contains about 3.4 per cent of protein, more than five sixths of which is casein. The fats are practically the same in both kinds of milk, being 3.7 per cent. Human milk has a greater percentage of milk sugar, namely, 6.4, while cow's milk has nearly 5 per cent. The mineral matters in cow's milk are 0.7 per cent., and in human milk 0.3 per cent.

The figures given are of course an approximate average. Different breeds of cows not only give different quantities of milk, but different percentage composition as well. It may be remarked that farmers should keep an individual record of each cow so that they may know how much milk each produces, and at what cost. It is considered by good judges that one quarter of the cows kept for dairy purposes do not pay for their keep, and that nearly another quarter yield no profit, leaving only one half to bring in money. Ayrshires, Jerseys and Guernseys may be expected to give about 6,000 pounds of milk in a year, while Holstein-Friesians may be expected to give 7,500–8,000 pounds. Individual Ayrshires and Guernseys have given over 12,000 pounds, nearly 17,000 pounds have been given by Jerseys, and Holstein-Friesians have frequently been known to give 20,000–30,000 pounds. The milk of the Holstein-Friesians is usually thin, low in total solids and lacking in fat. While the average fat for Ayrshires may be taken as about 3.6 per cent. and for Guernseys and Jerseys about 5.2 per cent., that of Holsteins is about 3.4 per cent.

The fat in milk is in very fine globules and forms an emulsion. Being lighter than the rest of the milk, it is separated by its specific gravity either by rising to the top on standing or by means of a separator. It is because of its finely divided condition that cream is more easily digested than other fats. In the case of Guernsey and Jersey cows the globules are larger than in other breeds and their milk is sometimes not considered so suitable for invalids.

Milk may be deprived of part of its water, thus making it more easily transported. The term "condensed milk" is applied to milk that has been partially evaporated and to which sugar has been added. "Plain condensed milk" means milk concentrated without addition of sugar and it is commonly sold in bulk. "Evaporated milk" is normal milk reduced to about half its original volume. It is similar in keeping

power to pasteurized milk and is chiefly used by confectioners and ice-cream manufacturers. Condensed milk if obtained from whole milk has about one third the original volume, if from skim milk one fourth. The condensation is usually effected in vacuum pans, by which means the water evaporates at a comparatively low temperature, thus changing the character of the contents but slightly. In 1912 the condensed milk factories in the United States had a capacity of about 15,000,000 pounds a day, the product probably of a million cows, though under proper conditions a million cows should yield a greater amount of milk.

A further step in the removal of water produces desiccated milk. The process, however, is quite different, for, in order to prevent change in the character of the solids, the evaporation must be very rapid. The milk is dried at a temperature of about 220–230° F. in about thirty seconds. When the milk powder is mixed with water in the proper proportions milk similar to the original is obtained. Approximately 90 per cent. of the desiccated milk manufactured is made from skim milk; the fat of whole milk is liable to become rancid on long keeping. Desiccated milk is completely free from bacteria; germs can not develop in it. The process is in use in many of the best dairies in Europe, also in Australia and the Argentine Republic.

A number of years ago an experiment was made in New York with 850 babies ranging from five days to a year old. Sugar of milk was added to the dried milk which was sometimes whole milk and sometimes different mixtures of milk and cream. This was fed during the four hottest months of the year. The mothers were instructed how to mix the powder with water and were told not to keep the milk any length of time after it was made up but to throw away whatever was left by the infant. Not a single child died. It was found that this milk did not clot in the stomach like ordinary milk, but in granular clots like human milk.

A very important characteristic of milk is that it is peculiarly adapted to the growth of lower organisms among which bacteria of various kinds are prominent. It is a food for them as it is a food for higher organisms. The souring of milk is brought about by bacteria which change milk sugar into lactic acid. These bacteria do not propagate by spores, and as it is spores that can stand the greatest variations of temperature the lactic acid bacteria are destroyed at a temperature not very high. Lactic acid bacteria are widespread, and it is almost impossible to get milk that does not contain them. As the milk sours the casein combines with the acid, forming a curd. When the milk begins to taste sour the growth of nearly all non-acid-forming bacteria is checked and in distinctly sour milk the bacteria are usually confined to two or three closely related varieties. Lactic acid bacteria are con-

sidered very beneficial in butter and cheese making, though usually thought to be objectionable in milk.

Besides the sour curdling of milk there is a sweet curdling similar to what takes place in the stomach when milk is drunk. The rennet of calves is used for the purpose. It contains what is technically called an enzyme. The curd is changed afterwards into a soluble material by another enzyme, pepsin. These are bacteria that produce similar enzymes and so a curd may be digested, as it were, by these bacteria. Sometimes the weather may be so hot as to be more suitable for these bacteria than for those producing lactic acid, and very little curd may be formed.

While speaking of casein it may be well to mention that when casein is subjected to great pressure it is converted into a ductile substance called lactite, which may be used instead of celluloid as an imitation ivory, for napkin rings, combs, handles of knives and walking sticks and for the veneering of furniture.

The typical lactic acid bacteria have, so far as known, no poisonous products and sour milk is probably valuable in many diseases, especially those which arise from putrefying bacteria in the intestines. Other bacteria which produce a ropy condition of the milk are also not considered harmful, but to most people ropy milk is disagreeable. The ropiness is due not to the curdling of casein, but to the bacteria themselves, which are held together by a slimy substance secreted by them. Koumiss, originally made from mare's milk, combines an alcoholic fermentation with that of lactic acid. The alcoholic fermentation is brought about in milk sugar not by the ordinary yeast used in making bread, but by a special variety.

Of course, the most important bacteria from the point of view of the consumer are the disease-producing ones. Epidemics of diphtheria and scarlet fever have been traced to milk, also typhoid fever and other diseases. It has been matter of debate whether tuberculosis is transmitted from animals to man, but the balance of expert opinion favors the view that it is. Tuberculosis is very prevalent among cows. In a test made at Washington on 1,538 cows belonging to 104 herds supplying milk to that city it was found that 16.9 per cent. had tuberculosis and this was considered to be below the average, which was estimated to be about 25 per cent. It is not uncommon to find 70–80 per cent. of a herd diseased.

Disease-producing bacteria are seldom isolated from or counted in milk. The total number of bacteria is counted and the count is usually merely an indication of how carefully the milk has been collected or the temperature at which it has been kept. If cleanliness has not been observed at all stages or if the temperature has not been kept down to about 50° F. or lower the bacteria are certain to number many thou-

sands and perhaps millions in a cubic centimeter. Hence for good milk it is important that the cows should be healthy and that the stables should be kept clean. The floors should be made of cement or some non-porous material so that animal waste may be easily removed; the walls should be smooth and without ledges where dust may gather and should be easily washed. Special pains should be taken with the ventilation, the air space for each cow should be at least 600 cubic feet, and there should be large window space, affording abundant light, since light is one of the best germicides. Moreover the cows themselves should be kept clean. They should be carefully groomed and even washed. The grooming should take place some time before the milking so that dust and hairs may not be floating in the air. It is an advantage if a building separate from the stable is used for the milking and that only.

The milker's clothes should be scrupulously clean; a white suit similar to that used by surgeons during an operation is to be recommended. The milk should be caught in a narrow-mouthed pail so as to admit as little dust as possible. The milker should not pass from one cow to another without washing his hands and the milk should be immediately taken to the milk house, where it should be cooled at once. Naturally the milk house must be clean; and all the vessels used should be sterilized by being kept for two minutes in boiling water or, still better, live steam. It is evident that the milk house must be abundantly supplied with hot and cold water.

No matter how carefully and cleanly the milk is produced, if during transportation and delivery it is open to contamination, the consumer is little benefited by the care exercised during the early operations. As soon, then, as the milk is cooled it should be placed in perfectly clean bottles and covered. The paper covers that are often supplied are better than nothing if they are reasonably clean but they are far from ideal. They are difficult to make and to keep sterile. In the "Uviol" method of bottling, tops are made of tin foil coated on the lower side with a germ-free stiffening material and kept in a germ-free package till required for use; and they are put on the bottle by machinery without being touched by the hands during any part of the operation.

The consumer must also observe care in the treatment of milk after it has been delivered. If there is disease in the house, special care is necessary; but many bacteria besides those of contagious diseases are detrimental to milk, some of them causing digestive disorders which in the case of babies may prove fatal. The vessels used for milk should be perfectly clean and the milk should not be exposed to flies and, as little as possible, to the air; and it should be kept cold. Flies are known to have caused typhoid fever; 100,000 *fecal* bacteria have been found on a single fly; while in a particular experiment in which 414

flies were examined there was an average of a million and a quarter bacteria of all kinds on each fly; and flies are common carriers of those bacteria that derange the intestinal system. Vessels used for milk should not be washed with the ordinary dish water but with fresh water. They should not be dried with a towel but should be rinsed with scalding water or still better boiled in water and set away unwiped but turned so that the water may drain out.

The growth of bacteria is inhibited either by low temperature or by high. While at 50° F. the bacteria increase about fourfold in twenty-four hours, and sixfold in forty-eight hours; at about 70° F., they multiply more than 6,000 times in twenty-four hours and nearly 400,000 times in forty-eight hours. These numbers are only typical of the order of growth which varies with different kinds of bacteria, but they illustrate the fact that it is very advisable to keep the temperature down to 50° F. or even better to 40° F.

On the other hand, a sufficiently high temperature destroys microbic growth. This temperature is above the boiling point of water and must be applied under pressure. Such a process is called sterilization. But this high temperature changes the character of the milk, and the growth of bacteria can be much lessened at a lower temperature by the operation called pasteurization. Two processes of pasteurization have been adopted; in the "flash" method the milk is exposed to a temperature of 160° F. for thirty seconds, in the "holder" method it is maintained at a temperature between 140° and 150° F. for thirty minutes. This last method may be carried out in the containing bottles if desired. At 145° F. all of the *disease* germs are destroyed and the majority of the others as well. At this temperature with long exposure a greater number of the putrefying germs in proportion to the souring germs are destroyed than by short exposure at a higher temperature, and as the putrefying germs are the most detrimental, the longer process is the better. Pasteurization does not prevent future growth of bacteria, which propagate with rapidity at blood heat. So after pasteurization the milk should be cooled immediately to a low temperature and kept at a low temperature till required for use. Sometimes thermos bottles are employed for keeping warm, through the night or during a journey, milk intended for babies. If the temperature is sufficiently high, say 145° F., most bacteria do not develop, but on the other hand some whose action is unknown grow in large quantities and if the temperature should fall to 100°–110° F. many bacteria develop so rapidly that in three or four hours the milk is quite unfit for infant's food. Thermos bottles may be used for keeping milk on a journey; but only for keeping it cold. If placed in a thermos bottle at about freezing temperature it will probably keep cool for a long time.

Eighty-eight per cent. of the milk supplied to New York is pasteurized, and 80 per cent. of that supplied to Boston.

In view of the importance of having milk that can be depended upon, medical milk commissions have been established, of which there are less than a hundred in the United States; in Canada there are only two or three. These commissions provide inspectors who frequently examine the herds to see that there are no diseased cows and that the employees are healthy, that the stables and other premises are clean, that the milk is properly treated and cared for during transportation and that it is delivered as soon as possible, thirty hours being the outside limit.

The milk itself is analyzed, the solid contents must be within certain limits and the number of bacteria must be low. Score cards are kept in which certain values are assigned to each feature and in order to be certified the milk must total a certain percentage. The lowest score of a certified dairy of which in 1913 there was any record in the U. S. Bureau of Animal Industry at Washington was 73.6 per cent. and the average of thirty-seven certified milk farms was 90 per cent. At the same time 953 dairies supplying milk in the ordinary way were scored and the average was 41.6 per cent.

About one half of one per cent. of the milk supplied in the United States is certified. The cost is approximately double that of ordinary milk, a matter of consideration to the general consumer but of practically no importance where the health or indeed the life of an infant may be concerned. It should be noted that certified milk is not pasteurized, but is cooled immediately after milking.

It is naturally where milk is to be used by infants that the greatest care is necessary. Every effort should be taken to make the replacement, where necessary, of mother's milk by cow's milk as little injurious as possible.

At Berlin, in 1885, when doubtless hygienic considerations were less attended to than now, the mortality among infants under a year old was that given by the following table:

Infants Fed by	Death Rate per 1,000
Mother's milk	7.6
Nurse's milk	7.4
Animal and human milk	23.6
Animal milk alone	45.6
Animal milk and milk substitute	74.8

So in children's hospitals, children are fed with milk made as nearly like human milk as may be, and every pains is taken that it shall be thoroughly hygienic.

Several years ago Dr. Ralph Vincent, senior physician to the In-

fant's Hospital, Westminster, wrote an article in *Science Progress* upon the milk supplied in that hospital. He pointed out that while well-nurtured children easily get over infectious diseases, badly-nurtured ones recover with difficulty and that complications usually arise. He discussed the contaminated character of the milk supply, especially among the poor of large cities, explained that contaminated milk when boiled is still contaminated and asserted that among the poor the boiling of milk plays an important part in the production of the most fatal disease of infancy, zymotic enteritis, which is largely caused by the putrefactive decomposition of boiled milk.

The milk used at the hospital is very similar to that demanded of certified milk by the medical milk commissions, but in some respects special precautions are taken. There is a rigorous supervision of the diet of the cows. No oil cake nor brewers' grain nor distillery grain is allowed, but grass, hay, pea and bean meal, and mangolds are the chief food. Jersey and Guernsey cows are not admitted to the herd, since the large fat globules are considered too indigestible for invalid children. The milk is delivered within four hours after milking.

Cow's milk has less milk sugar and more casein than human milk. When casein is separated from milk by means of rennet the whey contains the albumin as well as the milk sugar or lactose. The fat content in human milk and cow's milk is the same, so dilution of the milk by addition of whey would make the fat content too low. It is found best to separate the fat from the milk and to mix skim milk and cream in the proper proportions afterwards. Human milk is alkaline and lime-water is used to produce the required condition.

Mother's milk varies with the age of the child as well as with the individual; and in the hospital the nurses make up the food for each infant according to prescription of the six ingredients, of which some are artificial solutions, provided for the purpose. The following is a typical prescription.

	c.c.
Cream (32 per cent. fat)	75
Lactose solution (2 per cent.)	121
Whey	858
Fat-free milk	59
Lime water	60
Sterile water	27
	1,200

The milk mixture is then carefully put into separate bottles, one for each feeding. Many thousands of such combinations are used at the hospital. The milk is kept at 40° F. and the constituents are kept at the same temperature or lower. Just before the milk as modified is given to the infant it is warmed to 100° F., but none of this that is left is kept over for use at a later time.

It might be thought that milk produced with so much care would necessarily be expensive, but Dr. Vincent states that due to economy, among other things by having no cows that do not give a good return for the cost of keep, the expense is not greater than the average for ordinary milk and in fact that the hospital pays only 75 per cent. of the average price of ordinary milk in the metropolis of London. It would seem that in American cities it ought to be possible to procure milk of the grade of certified milk at a less advance beyond the ordinary price than is usually charged.

As old age comes on it appears that milk again becomes a specially valuable diet. In this case buttermilk and other fermented milks are said to be particularly suitable. This subject is, however, not one to be taken up at the end of a paper.

GEOLOGY AND PUBLIC SERVICE[1]

By Dr. GEORGE OTIS SMITH

DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY

THE subject on which I have been asked to speak presupposes a science that is practical—one that serves others than its devotees. It is only utilitarian geology that I shall discuss—that side of the science by some termed economic geology, by others applied geology; but for utilitarian I shall take the definition credited to Tolstoi—solely what can make man better. This human side of scientific work is simply part and parcel of its wider purposes, and to recognize its utility is to ennoble science rather than to degrade it.

Five years ago, in the presidential address of the Geological Society of Washington, Mr. Brooks gave some quantitative expressions of the marked tendency in geology toward practical problems. This growth in the utility of our science during the last quarter of a century was measured by the activities of state geological surveys and of universities, as well as of the Federal Survey. Further, as Mr. Brooks pointed out, the trend that has made applied geology the dominating element in our science has not been limited to the North American continent; it has been world-wide.

The United States Geological Survey was created for public service in the widest sense. Congress intended it to be a large factor in placing "the work of national development and the elements of future prosperity upon the firm and enduring basis of truth and knowledge." To quote further the language used in the debate of thirty-eight years ago, "the institution and continuance of an effective geological survey" was then regarded as a measure such "as will prevent the waste of natural resources, clear the way of progress, and promote the triumphs of civilization." Such a declaration of purpose, though more eloquent, was in full accord with the report of the National Academy of Sciences and surely leaves the federal geologist free to devote his science to public service, without fear of just criticism.

The present status of our science forecasts an even larger usefulness in the future. In oil geology alone the profession has won a place in the business world undreamed of 10 or even 5 years ago. When we see single corporations having in the field more oil geologists than the United States Geological Survey, we realize that our federal service must rest its claim to consideration on something other than size.

[1] Address given before the Geological Society of America, Albany, N. Y., December 27, 1916.

In other lines, too, the science of geology is gaining the recognition that we perhaps feel has too long been withheld. Especially gratifying is the tendency of constructing engineers to consult geologists in matters related to large engineering projects. To the trained geologist, familiar with the many kinds of rocks and their varied habits of assembling together, it has seemed strange indeed that so many engineers have gone ahead on the theory that rock is rock and that nothing can be learned of the third dimension of the earth's crust in advance of actual excavation. Possibly, however, some of this blame may be laid at our own door, for geologists do not always seem firm believers in the practical side of their own science, and only in these later years have we learned to talk of the facts of geology with any approach to the quantitative exactness that engineers expect. Even now a wide difference in degree of scientific accuracy and refinement may be noticed in the manner in which we handle data in our own particular specialty and data relating to some other phase of geology or to another branch of science. This lack of respect for specialized science may sometimes be found in our own midst, even though we call ourselves specialists.

The opportunities for expansion are plainly before us, for the practical worth of geology is now widely acknowledged. How can we best increase the contributions of geology to mankind? Has the science other possibilities? What is its relation to public service?

In the last three years it has been gratifying to see the preparedness issue broaden so as to include the contingencies of peace as well as of war, to hear of industrial as well as of military preparedness. But back of both, and indeed including both, there needs to be a more vital preparedness—the preparation for citizenship. In any day and generation this test can and should be applied to any religion, philosophy, or science: Does it make good citizens? It is therefore with real concern that we ask ourselves this question: Does geology contribute to citizenship?

The president of this society in a thought-inspiring address at the University of Chicago convocation this year, made reference to a little red-brick building here in Albany, which this city does well to preserve —the laboratory of James Hall. And I believe Doctor Clarke is right in regarding that small and plain structure as the source of broad conceptions of the philosophy of evolution, which, radiating outward, have influenced not only our science, but also your state and our country.

The sciences of geology and astronomy are founded upon postulates which they in turn have done much to make real—the permanence and universality of natural laws as we of to-day know them. By training and almost by second nature the geologist may be a conservative in politics; at least, the believer in natural law should possess the patience to wait for results in this particular epoch of this geologic era. By

training the eye to see far back into the earth's remote past, geology can add to our power to put correct values on the events and changes in the brief present in which we happen to live.

There is another way in which geology especially contributes to the training of an enlightened citizen. Some one has said that a man's breadth of mind is measured by the diameter of his horizon. Geology as a study and especially as a profession leads to wide travel, and travel surely maketh the broad man. This advantage may seem to us so much a matter of course that we underestimate its silent influence in fitting us for citizenship. The geologist has the opportunity to think in terms of country rather than of community, of continents rather than of country; and his broader outlook over the world surely gives perspective, just as his longer view back into the past gives poise.

In an address at the University of Illinois I referred to the inspiration and incentive which come from Professor Chamberlin's conclusion that there is good reason for measuring the future habitability of the earth in millions or tens of millions if not hundreds of millions of years. This belief in the high probability of racial longevity is, as you know, the result of an exhaustive analysis of the past as revealed by geology and of the future as forecast by astronomy. But now I wish to add my personal acknowledgment to our greatest American geologist for the inspiration gained from a talk with him several years ago, when I realized that it was this scientific expectation of the evolution of humanity continuing through these millions of years that was prompting him to public service not limited to his own city or country.

The geologist's appreciation of that delicate adjustment of earth to life by means of which "life has been furnished a suitable environment for the uninterrupted pursuit of its ascensive career" and the geologist's vision of the continued adaptation of the earth to the uses of man together constitute a real call to larger service. No one has more reason than the geologist to believe that wise utilization of nature is essential, now that man the engineer has become so effective a geologic agent; nor can the geologist overlook the need of a social organization that will adequately serve the larger and higher demands of humanity, now that man himself controls in large part the adaptation of this earth to man in his further evolution. We believe that the Golden Age is in the future, but it will be of man's own making.

This tribute was paid a year ago to the work of the geologist and engineer by one in high official position who has a vision of things as they are and are to be—Secretary Lane:

> This is a glorious battle in which you are fighting—the geologist who reads the hieroglyphs that nature has written, the miner who is the Columbus of the world underground, the engineer, the chemist, and the inventor who out of curiosity plus courage plus imagination fashion the swords of a triumphing

civilization. Indeed, it is hardly too much to say that the extent of man's domain and his tenure of the earth rest with you.

Keeping in mind these thoughts of the larger things of time and space, I desire to mention what may be termed the professional obligations of geologists. As scientists, working in a practical world on problems that have come to have very practical bearings, we may need to take special care that our scientific ideals be not lowered. As an associate in a large group of geologists I have been proud to see the science of geology win this larger recognition in the market-place, for I hope to see our science cooperate in the further raising of business ideals. There can, however, be no double standard for geologists—one for guidance in research work in pure science, the other for purposes of professional exigency. As geology enters into the larger sphere of usefulness, there naturally come to the geologist opportunities somewhat different from those of the laboratory or lecture room. The profession in its newer activities encounters stresses for which new factors of safety must be figured. As I look at the demands now made upon geologists, the temptation to lower our ideals comes not so much when our task is to find something as when we may be called upon to prove something.

The geologist sent to South America to determine the extent of an ore body or to Oklahoma to discover an oil pool must needs bring into play every resource of a trained mind in order to wrest the truth from secretive nature. This is a contest which calls for geologic science at its best, and in which scientific ideals are in no danger. A demand of another kind, however, is made upon the geologist who is asked to certify to some doctrine in the conservation creed, it may be, or to testify in support of some contestant in a court of law. Professional demands of this type may cause our scientific ideals to tremble, if indeed they do not suffer a tumble. It is for this reason that a geologist's ideals are safer in the field than in the court-room; Mother Nature is a better associate than the goddess who goes blindfold.

Yet the problem faces us and we must answer our own question: What are the professional obligations of the geologist? Possibly the official geologist is less exposed to temptations of this type; he is allowed to make his testimony follow the evidence. At least I remember that the Survey geologist published, uncensored, his estimates of coal reserves, even though his statement did not fit in with the popular argument for conservation; nor was the official opinion required by the statute as to the influence of forests on stream flow given until field examinations by geologists and engineers furnished a basis of fact; nor again do I believe that the federal geologists who testified as to the mineral character of petroleum were in any degree influenced in their opinion by the chance circumstance that this was the government's con-

tention. On another occasion the federal geologist whose duty it was to defend the official classification of land in a western state had definite instructions to reverse the Geological Survey's position in the matter if new evidence should indicate an error of judgment, even though such action would have enabled the railroad claimant to win the land. Nor should a government geologist hesitate to file notice of a correction in some assays earlier introduced as evidence, even though he thereby strengthened the land claimant's contention. Here, of course, the issue was plain; the duty of the public servant was to see that truth prevailed, even though the government might seem to lose its case. In two other of the instances I have mentioned some degree of temporary popular favor and freedom from current newspaper criticism could have been gained by a different course, but I believe that in the end the good name of science would have been besmirched.

Yet in courts of law we now see geologists testifying as experts on both sides of the case, and too often as experts on subjects on which they would not be regarded as specialists by their fellow geologists, or at least on specialized phases of geology which they themselves might hesitate to discuss before this society. But even when such opposing witnesses are both eminently well qualified, what is the spectacle presented to the public? One expert testifies that the thing under discussion is absolutely jet-black; the other that, as he sees it, it is purest white; whereas it may be that without the legal setting the same thing would present to most of us varying shades of gray, or perhaps some one using a higher power of lens might call its general color effect rather spotted. I regret to add that this suppositional illustration is almost paralleled by an important case in which two of my own friends, both honored fellows of this society, were the opposing expert witnesses; and afterward the judge told me that he could believe neither, although he would have taken the unsupported opinion of either one had this geologist been in the pay of the Court! Does not such a statement by an eminent jurist put geologic experts on a par with other expert witnesses, and would it not be a "safety first" measure for geologists to decline professional work of this type until the day comes—and I think it is not far off—when the court will summon the expert witness and compensate him for his services to the state in telling the whole truth and not that special part of the truth which favors one litigant? This society wisely put itself on record last year as recognizing the urgent need of this reform in legal procedure, but to be effective resolutions need to be adopted by each individual geologist.

As first suggested to me, the subject on which I was invited to speak to-day was geology in the national service, but I feared if thus expressed my topic might seem to limit opportunities for service to the nation to those of us who are on the Federal Geological Survey. The president

and more than a score of other fellows of this society are in the public service as officials of the several states; and too much credit can not be given to the long succession of state geologists who for nearly a century have both contributed to the science of geology and guided the development of their states. A few years ago Doctor White, in addressing the West Virginia board of trade as its president, referred to the function of the state geologist as that of "a kind of mentor or guardian of the state's natural economic resources."

Yet I would not limit the obligation for public service to those of us who happen to be public servants. The use of the United States Geological Survey as a training school for professional geologists in private practice can not be regarded as wholly a hindrance to the nation's business when viewed in a large way. The spirit of public service can be carried over into the work outside the official organization, and I like to believe that there is a persistence of this same purpose on the part of our Survey graduates that will lead them to do their share in planning for the utilization of the nation's mineral wealth, not merely so as to increase dividends for the corporations that employ them or to assist a few capitalists in speculative endeavors to corner some limited resource, but also so as to benefit society in a large way through future decades. Why can we not be trained scientists and professional geologists and loyal citizens at one and the same time?

President Vincent has referred to the sweeping indictment of professional schools, with all their modern efficiency, as turning out graduates "bent upon personal success and regarding the public as a mine to be worked rather than a community to be served." In whatever degree unwarranted, this criticism, as President Vincent points out, is in itself encouraging as a sign of general discontent with self-centered careers. And there is another approach to this subject of the civic obligations resting upon us as geologists. Those of us who have shared in the benefits of the American educational system, up to and including the university, must realize to what a large extent our education has been gratuitous. As Doctor Becker once expressed it to me: "Men who seek or use their university training solely for their personal advantage are almstakers. Only by public service can educated men repay the debt they incur and thus fulfil the designs of the founders."

It is a fortunate sign of the times that applied science is touching more and more upon the human and social side of its work. Measure of the breadth of view already attained in this public service idea is found in this month's issue of a leading technical journal, *Metallurgical and Chemical Engineering,* wherein the longest editorial bears the title "Expensive Slums." Social responsibility is acknowledged and civic duty set forth in the closing sentence of this editorial:

> It is needful for industries that they be in good standing, and they can not maintain good standing so long as they have slum attachments.

So too it is eminently fitting that in a technical volume bearing the title "Iron Ores" the closing chapters should discuss the large social questions of public and private policy. The author, a geologist and fellow of this society, properly regards the social value of iron just as worthy of his thought as the purity of its ores. Indeed, it is simply the need of society that makes the mineral hematite an ore and thus the object of the geologist's special study.

In my administrative report for the past year I had occasion to refer to a professional paper by Doctor Gilbert now in press. In his wonderfully broad and complete investigation of the mining-débris problem in the Sierra Nevada the geologist began with the antagonism of mining and agriculture, but he soon found that his research also involved questions of relative values between commerce and irrigation and power development. So this report, thoroughly scientific in data and method, will illustrate how high a public service can be directly rendered by the geologist. Nor is this a new departure: some of us belong to the generation to whom Monograph 1 of the United States Geological Survey was a source of inspiration in our student days. That monumental work by the same author, a classic in its exposition of geologic processes, was the result of an investigation also planned as the answer to an economic question of large civic importance. Director King thus stated in 1880 the purpose of the Lake Bonneville monograph:

> Is the desert growing still drier or is it gaining in moisture are questions upon the lips of every intelligent settler in that region.

Moreover, aside from making our science more human, there is the larger need of humanizing ourselves. Doctor Favill, of Chicago, in addressing a group of business men last winter, gave them this professional advice: "Have an outside interest;" and the outside interest he prescribed was political or social activity. This physician regarded it as conducive to individual happiness as well as helpful to society that "every honest, able-bodied, red-blooded, clear-thinking man should have his mind set on what is the right thing for him, for his community and his country to do."

The Austrian geologist Suess may furnish the best illustration of the happy combination of scientist and citizen. He was a leader not only in the science of the world but in the parliament of his country. A close student of geologic discovery even after reaching fourscore years, Professor Suess was equally keen to learn of political progress the world over, and in a letter to me within a year of his death he inquired particularly about the reforms in public-land administration in the United States.

Appreciation of civic duties has fortunately not been lacking in

American geologists: one of the best volumes on citizenship was written years ago by Professor Shaler, and it is worthy of mention that in that book he emphasized not so much the opportunities for service in high station, for he states that the best work in the practise of citizenship is done in the town or precinct.

> In these fields of activity the spirit of the freeman is made; if the local life be not of a high citizenly character, all the constitutions in the world will not give the people true freedom.

And it has been said of Professor Shaler that he not only preached good citizenship, but, what was better, he never neglected his own political duty. While we must properly look upon enlightened citizenship as a 365-day-a-year undertaking, there is one day in each year, or two years, or four years when a special duty is laid upon each citizen of the state and nation, and in these times no one is better qualified to exercise the right of suffrage than the geologist. A few weeks ago, too, we learned that even in this great country of ours, where eighteen million ballots were cast at a single election, individual votes have not lost their power to influence the result. And how true it is that education of the scientific type is essential to a correct understanding of many of the issues of the day.

In a leading editorial, the day before election, a nonpartisan writer mentioned the discussion of prosperity as a campaign issue and remarked that

> Analysis of the interminable political arguments about it would probably disclose that in the main they consist of about 95 per cent. imagination and exaggeration, in equal proportions, 5 per cent. of fact, and of unbiased opinion not a trace.

A low-grade ore of that composition surely needs a citizen who is a scientist or engineer to make the necessary separation and concentration.

Take another political and economic issue that must be faced—the length of the working day. Professor Lee, of Columbia, recently emphasized the fact that the determination of the proper number of hours of work is primarily a problem of physiology, although too often economic and social considerations have been made paramount. Must we not agree with the physiologist, at least to the extent of admitting that it is all too evident that here is a present-day issue of large importance which deserves scientific rather than political treatment? Or we may say, here is a civic question that demands the attention of citizens who have had scientific training. Who can better weigh the opposing elements of this question—on the one side the cumulative fatigue of the individual producer and on the other the economic requirements of society as the consumer?

To mention just one other of the larger issues of the moment, the

railroad question is one so intimately tied up with the geographic relations of mineral resources that the geologist citizen is eminently well qualified to consider how dependent is industrial opportunity upon fair freight rates. When we realize that the railroad earnings from the transportation of the raw products of the mine alone exceed the earnings from passengers and also exceed the freight receipts on all products of both farm and forest, we have a measure of the interdependence of the mineral industry and the railroads. The proper regulation of common carriers thus becomes a prerequisite of the full utilization of our mineral resources, and on such a political issue no citizen should have a larger interest or a more intelligent opinion than the geologist. It is therefore more than a happy coincidence that President Van Hise has rendered large service to society in his contributions to the railroad and labor problems; the broad training of the geologist is being utilized in the work of the publicist.

Have I not already shown that the geologist is well qualified by his special training to serve his day and generation, not only in the capacity of professional adviser but, better than that, in the rôle of fellow-citizen? It may be rather late in this discourse for me to select a text, but there is an old saying in the book of Proverbs that has been much in my mind for several months—"Where there is no vision the people perish." Imagination is necessary in our science, and it is equally essential to the larger citizenship. I believe the geologist possesses the vision; his duty and privilege is to let that vision guide him to a larger public service.

ADVENTURES OF A WATERMOL

A Romance of the Air, the Earth and the Sea. II

By Professor H. L. FAIRCHILD

UNIVERSITY OF ROCHESTER

Synopsis of the Preceding Chapters: In the January number of the Monthly the water molecule tells of its birth, in an ancient volcano perhaps one hundred million years ago, and relates some of its romantic experiences, in the atmosphere, cloud, ocean, glacier and iceberg.

In the Ocean Abyss

THE water in which I was liberated from the iceberg was fearfully cold and heavy and the polar current carried me slowly down to great depth in the abyss of the ocean. It was terribly cold and the pressure was immense, even more than in the glacier. I went down to near the bottom of the deep ocean, down 20,000 feet, I should think. Though the temperature was below that for freezing at the surface, the pressure and the salt substances which we watermols held in solution prevented our turning into ice.

To this great depth the sunlight never reached. At lesser depths there was a faint light or phosphorescence produced by curious fish and other animals. It was a weary, weary time; perhaps not worse than in the glacier, but different. In the glacier, as I have said, it was a sort of frozen silence. Here it was a liquid solidity. In the glacier we watermols were kept in stillness and idleness, while here in the ocean deeps we yet had cold and darkness and crushing pressure and besides we had to keep in captive subjection the many substances which are found in sea water.

Very slowly the cold water in which I lay drifted toward the equator. But it took long ages of time before we reached the equatorial region. In the warm tropics the watermols at the surface of the sea are stolen away so rapidly by the air that the deeper water very slowly rises to fill the space. Slowly, dreadfully slowly, I was lifted upward. Maybe it was a million years until once more I was at the warm surface of the ocean.

In Tropic Seas

Floating about in the warm water of the tropic sea in the bright sunshine and with many curious animals swimming about was much nicer than being in the frozen heart of a glacier or in the silent pres-

sure of ocean abyss. And curious adventures befell me here. Once a frond of seaweed seized me and built me into its pulpy mass, and as a part of the plant I was floated about the sea during all the life of the fucoid, which must have been more than a century. Once a big sea-jelly, or so-called jellyfish, gulped me down into his baglike stomach and sent me in the current through his many tubes or canals, and then he added me to his soft, watery flesh. But one day the angry waves in a big storm dashed my seajelly on the rocks and he was beaten to death, and in the decay of his substance I was liberated. Many of the different kinds of animals which live in the sea have, at one time or another, made food of me and have carried me into their flesh or the cavities of their bodies. I may mention the coral polyp, the sea urchin, the oyster and the devilfish. But the animals all die, while I live on. My adventures with some of the larger and higher animals will be told later.

When free in the ocean my fellow watermols and I were always busy, holding in captivity or solution the molecules of many gases and solids. In later times, more than once I have been in the water current that was sucked through the gills of a fish or other animal when molecules of oxygen were taken away and carbon-dioxide molecules given back in exchange.

I have been in all the great currents of the ocean, such as the Gulf Stream, and have felt the daily tides for many millions of years. I have been in the spray on the crest of storm waves, and in the white foam of breakers on the shores of coral islands.

During this episode of which I am telling, the tides and currents of the tropic seas drifted me about for a long time, until one hot day when I was lazily resting at the very surface of the water I was grasped and pulled away from my fellow watermols by the warm air, and again was floated far away in the atmosphere, a captive of the nitrogen molecules.

In a Subterranean River

Sometime, it was certain, I should be again dropped on the sea or land. And again I was built into a raindrop. After helping to carry the electricity of a terrible lightning storm I fell on the ground in some faraway land. The ground absorbed the water and I went down and down into the earth. Finally I fell in a little stream which came out as a spring on a sunny hillside. Flowing down the slope and then a long way down the valley the little stream joined a small river. Many miles further the river passed beneath the surface of the ground and plunged into a subterranean channel in limestone rock. Finally it carried me into a lake in a great cave in the limestone. For years I was there in darkness. This was a new experience.

Like the depth of the glacier, and the ocean, it was perfectly dark. But it did not have the great pressure and the extreme cold. And there were no waves and no strong currents because there were no winds. It was a tiresome place. I only had to help hold some calcium carbonate in solution.

All the underground river channel and the cave had been the work of other watermols, my predecessors, for thousands of years. But not only had they dissolved and removed the rock to make the cave, but to show that they could build as well as tear down they had formed beautiful objects in the cave as samples of their construction. Long masses of translucent limestone, of white, yellow and pink color, and shaped like icicles, were left hanging from the roof of the cave-stalactites. In some parts of the cave, which the lake did not cover, conical, needle-shaped and columnar masses of the same elegant material rose from the floor-stalagmites. The beautiful material called "Mexican Onyx" is of similar origin. Some other examples of our constructional work are the lime deposits made by hot water in the open air, as at Mammoth Hot Springs.

Very slowly the drift carried me through the lake and finally out of the subterranean channel into the open air and light.

In a Coal Plant

The river in which I floated out of the ancient cave carried me into some lake, and after a time I was again taken up by the air. And again I was in a raindrop and fell upon the ground, and sank into the earth. I wondered what new experience was coming; and the event was unexpected. Some of my fellows were drawn back into the air, which was always seeking to keep us. But I sank deeper in the earth. I was drawn along between the mineral grains which composed the soil, by the attraction called tension or capillary attraction. Then I lay close against the tiny rootlet of a tree. The rootlet took violent hold of me and drew me right through its wall and into its interior. In a watery fluid I was then carried into a larger root; then into the trunk of the tree: then up the tubes or ducts of the wood; out into a branch; into a branchlet, and at last into a leaf. All this time I was compelled, with multitudes of other watermols, to carry along other substances which the tree required for food. These were mineral compounds containing nitrogen, phosphorus, sulphur, potassium, etc. We watermols were the food-bearers for the tree. Our ride in the sap of the tree was not free; we had to work our passage.

In the leaf we assisted the tree in preparing and digesting its food. I was helping in the life and growth of one of the strange trees of the Coal Period, called Lepidodendron. And actually I was helping to

Courtesy of Eastman Kodak Co.

FIG. 12. WATERMOLS ATTACKING THE CONTINENT.

produce coal, in China. By the green substance in the leaf, known as chlorophyll, the tree was able to draw a supply of power from the sun. Carbon-dioxide was taken in from the air and broken up. The carbon was kept to unite with us watermols and the oxygen was given back

FIG. 13. WATERMOL ARCHITECTURE.

FIG. 14. WATERMOLS TEARING DOWN THE MOUNTAINS.

to the air. The substance of the tree was built up from us watermols and the carbon of the air. Many of my fellows were used as food for the tree and were built into its wood. I have been told that this par-

E. H. Barbour, photo.

FIG. 15. WHERE WATERMOLS UNDO THEIR OWN WORK.

ticular tree in its old age fell into the marsh in which it grew, and became part of the peat deposit which is now a coal bed one thousand feet in the earth. Some of the watermols which worked with me in the sap and leaf were built into the wood of that tree and are now down in that ancient coal deposit. More than once have I just escaped such fate. But after being employed in various kinds of chemical work, and in carrying sugar to the tissues of the tree, I was fortunate in escaping. One bright day when I was near the surface of the leaf I passed out, by evaporation or transpiration, into the freedom of the air and sunlight.

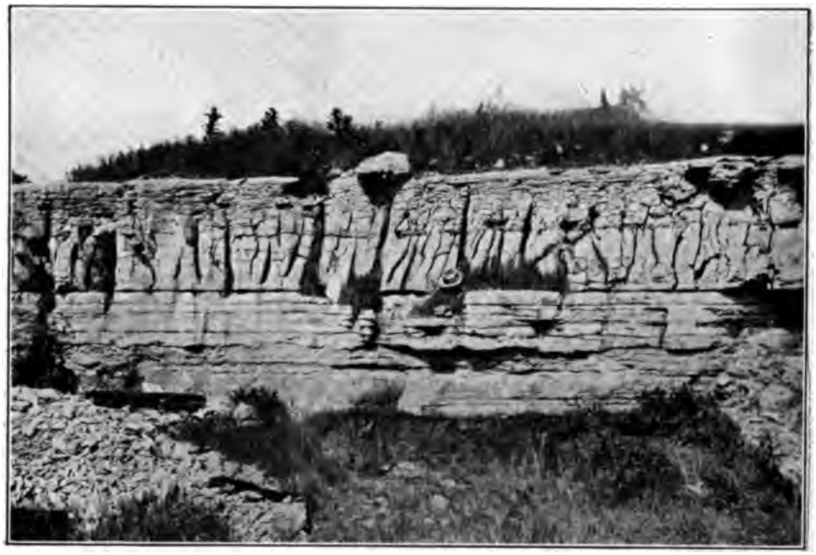

Fig. 16. Limestone Beds Deposited by Watermols.

Almost a Planet

Again I was up in the sky, with more freedom of vibration, the happiest of all the many conditions I have found. I knew that sooner or later I would be carried down to earth again by snow or rain. But this time I was driven by collisions with other molecules on and up and up until I was far from earth and out in the very rare atmosphere. Here all the molecules, nitrogen, oxygen, hydrogen, and we water molecules, were farther apart, with less interference, fewer collisions and longer free paths of vibration. The elastic rebound from some collisions gave certain molecules, especially hydrogen, such velocity in outward paths (critical or parabolic velocity) that they passed beyond the earth's control, the earth's effective gravitational pull, and were lost to the earth; though not lost to the solar system. At times a lucky (or unlucky) rebound might have thrown me so far away that the earth-pull could not entirely check my flight and draw me back. Then

FIG. 17. A LITTLE BIT OF WATERMOL WORK.

I would have been a really free molecule in interplanetary space and would have had my own independent orbit around the sun. Ah! then I would have been a planet of the solar system, a single molecule, a little brother of the earth and Jupiter. Perhaps it were more correct to say, a little child of the earth and nephew to Jupiter. Multitudes of watermols and molecules of lighter gases, as hydrogen and helium, have left the earth and are either moving in space about the sun or have been captured by the planets or the asteroids. As the sun's effective attraction reaches far beyond the orbit of the most distant planet probably few molecules could ever escape into stellar space. It is believed that the present ocean and hydrosphere does not represent all the water

which the earth has exuded or perspired, especially in its early or youthful stages, when it was smaller and its attractive power was less. But to counterbalance this loss it is probable that the globe has acquired many watermols and other molecules which had been wanderers in space, having been expelled from the sun, or perhaps were lost children of the other planets or emigrants from the moon.

That would have been a far leap for me, into the deep abyss of space. I was too timid, and clung to the atmosphere. When I bounded into space I took an elliptical instead of parabolic curve and so returned. I resisted the temptation of becoming a tiny planet all by myself: a little rival of the planets and asteroids. But, after all, it would not have been a very vainglorious existence, because no astronomer would ever have discovered me. I should have remained unknown,

FIG. 18. WATERMOLS REMOVING THE LAND.

a lost watermol wandering in the infinite spaces, unmissed and useless. And yet! according to the law of gravitation the great sun and even the distant star-suns should have felt the pull of my attraction. But such a tiny pull!

However, some day, if I survive long enough all the dangers that face a watermol and have grown tired of the earth, I may venture the leap to outer space and abandon this old sphere and let it take of itself without my help.

IN THE SOUTHERN HEMISPHERE

So I remained in the captivity of the air, and the swift currents of the outer atmosphere carried me downward and far southward, and I found that I was in the southern hemisphere.

It would be tedious to relate many of my adventures there, as it would repeat some already told. The time was early Mesozoic, or the Period of Reptiles, and I met some of the queer plants and queerer animals of the ancient reptilian time. The lakes and rivers and clouds and storms, and halos, coronas and rainbows that I helped to form were not unlike those of all lands in any time. But the life of different lands during the several geologic periods was very changeable, and this gave variety to my existence.

I was long immersed in the waters of the South Pacific ocean, which at that time was not so large as to-day, because the dry land in the southern hemisphere was more extensive and the southern con-

Eastman Kodak Co.

FIG. 19. WATERMOLS AS ICE DECORATION.

tinents were then connected. I fell in with some of the huge swimming reptiles. One was fish-like in shape, with paddles, and perhaps thirty feet long. He had an enormous mouth for seizing fish and a multitude of sharp conical teeth. This was the Ichthyosaurus, but I doubt if he knew his name. Another one, the Plesiosaurus, had a snake-like neck and head on a short body. Among the big mollusks were the Ammonites, related to the modern pearly nautilus. Once on the land I saw some of the huge Amphibians of that and the preceding period. One was like an enormous frog, but had powerful teeth and bony armor, and was near ten feet long. How he could jump! The

FIG. 20. WATERMOLS ESCAPING FROM A GLACIER.

curious Cycad trees had some assistance from me in their life and growth.

For one or two hundred thousand years I was imprisoned in an Antarctic glacier. Once I fell in a storm on the east slope of the Andes mountains, and was swept down into the headwaters of the Amazon river, and helped to make that big river all the way to the sea. That landed, or oceaned, me under the Equator. There the warm and still air held me for a long time in the Zone of Calms. I just had to lie

around in the Doldrums, sometimes in the surface waters of the warm sea, and sometimes in the air. I do not remember just how I got out of the Doldrums.

Destroying the Continents

Let me interrupt the story to say that we watermols are chiefly responsible for changes in the land surfaces of the globe, and incidentally for making most of the fine scenery. Of course many of the best scenic features are credited to the Devil, but we are the real little devils that tear down the land. We do not like to see dry land standing up in the air. We think it should all be in our possession, nicely spread out on the bottom of the sea.

So we are always busily and persistently at work cutting away the continents and islands and carrying the detritus to the sea. Eventually everything on the surface of the land finds its way into the ocean, and we are the transporting agency.

If the continents will only stand still a little time we will get them. We would have destroyed them long ago but for the interference with our work by the interior forces of the earth—heat and gravitation. They deepen the ocean basin and crumple and raise the lands so that we have to do much of our work over again. At different times we have had most of the continental surfaces below our level and in our possession, but those terrible powers have lifted the sea bottoms into the air and we watermols have to pull them down over and over. But we are patient and tireless and keep right on at our task. When you stand at the ocean shore you see us always restless and sometimes fiercely tearing the shore. We have been doing this destructive work on the lands and constructive in the sea ever since the infant globe acquired an ocean, when it was somewhat larger than the moon, and we shall keep tirelessly at it as long as any land exists to challenge us.

We have many ways of attacking the land. As bees and ants have division of labor, so we watermols have our varied work; but we can change, and any of us can do any kind of watermol duty. Sometimes we simply dissolve the rock, such as limestone, salt or gypsum. As we made those rocks it is quite easy for us to reclaim them. Sometimes we merely dissolve the cementing material and cause the rock to fall to pieces. Then we wash the loose stuff down the slopes until our fellows of the creeks and rivers can grasp it. Our rivers make the canyons and the valleys. We are the valley-makers. Cascades and cataracts mark the spots where we find a little hindrance or delay in carving the valley. They do not last long. And the lakes are short lived, for the watermols there are too inactive; so we either drain the lakes by deepening the outlets or fill the basins with detritus.

When the air temperature is too low for us to exist and work as

S. Calvin, photo.

FIG. 21. TRACK OF A GLACIER.

fluid water we do not wait for a warmer spell, but get busy as frost and snow and ice. In high mountains and polar regions this is our favorite manner of working. The mountains do not last long. Nothing can stop our work of destruction or even discourage us. Here and there we may be hindered a trifle, but the mountains of to-day are big only because they are new, and in time they will be carried to the sea as we carried those of ancient time.

When we get the rock stuff fully in our possession we spread it out in beds—the fine stuff, like clay, in delicate horizontal layers and the coarser, as sand, in thicker sheets. In this way we have made the geologic record for many millions of years. In graceful wave lines and elegant ripples we have written our play time along the ancient shores; while in the even-bedded strata of clay or sand or lime, filled with the remains of the ancient animal and plant life of the sea, we have inscribed the wonderful record of the deeper or more quiet waters.

FIG. 22. WHERE THE WATERMOLS DANCED.

I have helped to make some of

your famous scenic features, like Yosemite and the Colorado canyòn, and have helped a little in pulling down the Alps and Sierras. I have been in many big and little waterfalls and lakes and streams innumerable. The next time that you stand before Niagara or by the Mer de Glace, or admire the quiet stream or the frostwork, look out for me. If I am not there it is because I have another job.

We watermols will all be working after you humans are gone from the earth, just as we were a hundred million years before you came. Perhaps if you would go back to breathing by gills so that you could live again in the sea you might survive longer. The ocean is the great reservoir of life, which may there persist after we have conquered the continents.

Why do we work so tirelessly? And do we work for the love of it? Well! motion, energy, activity is our nature; and we are restless for the same reason that the bird sings or the bee labors. Do you humans rush about like mad and strive and rob and kill each other just for fun, or because you can not help it?

(To be continued)

THE PROGRESS OF SCIENCE

THE NEW YORK MEETING OF THE AMERICAN ASSOCIATION AND THE ORGANIZATION OF SCIENCE

THE forecast of the meeting of the American Association and the national scientific societies affiliated with it, printed just before the meeting in the last issue of this journal, was fulfilled in all respects. As had been anticipated, it was a meeting of unprecedented size, not only in this country, but, as far as we are aware, in any other country. The attendance can only be very roughly guessed, for while the association gives an opportunity for members to register, not nearly all of them do so, as the only practical advantage is the obtaining of a program. Some of the affiliated societies keep a register of members in attendance, but these have never been brought together for the whole meeting.

The magnitude of the meeting can be best realized from the number of separate organizations in session. Apart from the general session of the American Association and its twelve sections, there were fifty-two national scientific societies meeting during the week, and this number does not include the four national engineering societies and three associations devoted to highway engineering, which held meetings in connection with the section of engineering of the association, the metric conference, the meeting of the Committee of One Hundred on Scientific Research and various other organizations.

Altogether about seventy-five different organizations met during the week and, while there was a considerable amount of overlapping membership, the sessions appeared to be in all cases well attended. In spite of the large number of simultaneous meetings, there was no overcrowding. Six or eight thousand people naturally made small impression on the hotels of the city, which in that week are less crowded than in the preceding and following weeks. Columbia University has in attendance some 10,000 students every day and only part of the meetings were held there. Teachers College, part of the buildings of which are shown in the accompanying illustration, has, counting the students in the Horace Mann School, some 4,000 students in attendance.

The present situation in Europe has attracted universal attention to two factors—the importance of science and the necessity of effective organization—and these are combined in the American Association for the Advancement of Science, which represents the science of the nation, and a tolerably efficient organization of its twelve thousand members for the accomplishment of their objects. The advance in science and organization since the American Association was established in 1848 is truly remarkable. It covers a period from the time when American contributions to science were comparatively few to the present meeting, from which we can probably date the time at which America has assumed leadership in scientific research.

Local societies concerned with the whole field of knowledge had been established in the seventeenth century, the Philosophical Society of Philadelphia following the Royal Society of London, and the Academy of Arts and Sciences of Boston following the Paris Academy of Sciences. The National Academy of Sciences was organized in 1863, with a membership then limited to fifty. Until the establishment of the American Chemical Society in 1876,

THE BUILDING OF THE TEACHERS COLLEGE WITH THE CAMPUS OF COLUMBIA UNIVERSITY IN THE FOREGROUND.

On the Columbia University Campus.

there were no special societies and the loosely organized American Association and the other societies mentioned were the only means of bringing together men in all the sciences then so little specialized that this was possible. In 1875, a formal division of the American Association was made into two sections, one for the exact and one for the natural sciences, and in 1882 nine sections were established. Parallel with the organization of scientific societies scientific journals were established, *The American Naturalist* in 1867, *The Popular Science Monthly* in 1872 and *Science* in 1883. The establishment of these general journals was followed by the establishment of special journals: the *Botanical Gazette* in 1876; the *American Journal of Mathematics* in 1878; the *American Chemical Journal*, the *American Journal of Morphology* and the *American Journal of Psychology* in 1877; the *American Geologist*, the *National Geographic Magazine* and the *American Anthropologist* in 1888, and so on, in increasing numbers to the present time. The Geological Society

HUGO MÜNSTERBERG.

The distinguished German Psychologist and Publicist, professor at Harvard University from 1892 until his sudden death on December 16.

of America and the present American Mathematical Society were organized in 1888, and in the intervening period have been established the large number of scientific societies which met together in New York during convocation week, and represented so impressively the development and differentiation of science in America.

DR. CAMPBELL'S PRESIDENTIAL ADDRESS ON THE NEBULÆ BEFORE THE AMERICAN ASSOCIATION

THERE were printed on the official program of the association the titles of some fourteen hundred papers to be given at the meeting. Among this large number the address of the president of the association, Dr. W. W. Campbell, director of the Lick Observatory, may be selected for notice, not only owing to its official character, but also for its intrinsic interest. The discoveries of astronomy make a strong appeal to the imagination, and it is noteworthy that this least practical of all the sciences is the one which in America has been cultivated beyond all the others, so that the work of the great American observatories is not paralleled elsewhere.

Readers of this journal are familiar with Dr. Campbell's work on the evolution of stars and on comets through the admirable papers we have had the privilege of printing in recent numbers. His presidential address was on the nebulæ, to which Sir William Herschel, towards the end of the eighteenth century, gave the first serious study. In 1845, it was determined by Lord Ross's reflecting telescope that some nebulæ are of spiral structure, evidence that they are in rapid rotation. In 1864, William Huggins discovered that the spectra of certain nebulæ prove that they are masses of gases, shining by their own light. The fourth event recorded by Dr. Campbell was the discovery by Keeler, beginning in 1898 at the Lick Observatory, that the great majority of nebulæ are spirals and that the Crossly reflecting telescope that he used could discover at least one hundred thousand nebulæ in the sky.

Dr. Campbell explained—his clear exposition was throughout accompanied by striking and beautiful photographs—that of about fifteen thousand recorded nebulæ not over three hundred, that is, not more than one fiftieth, are in the one quarter of the sky which contains the Milky Way, and these include nearly all the planetary and large gaseous nebulæ. The other three quarters of the sky contains nearly fifteen thousand nebulæ, not counting the scores of thousands as yet unrecorded. Thousands of spiral nebulæ are known to exist, but not a single one has been found within the Milky Way.

Our stellar system is believed to occupy a limited volume of space, somewhat the shape of a very flat pocket watch, and we see the Milky Way as a bright band encircling the sky, because looking toward it we are looking out through the greatest depth of stars. There is reason to suspect that there is an immense amount of obstructing material in our system, that would be most effective in its long dimensions. If such obstructions are operating upon the light of extremely faint and distant nebulæ, they should produce something like the distribution that is observed among the visible spiral nebulæ.

The probable mass of certain spirals is stupendous, some of them appearing to contain enough material to make thousands, and possibly millions, of stars comparable in mass with our sun. The spectra of some spirals have the characteristics that we should expect to find if they consisted chiefly of multitudes of stars. If we carried our spectrograph so far out into space that loking back our stellar system would be reduced to the aparent size of the spiral nebulæ, we should expect to see a spectrum similar to that yielded by the spirals. Dr. Campbell thus favors the hypothesis that the spiral nebulæ are enormously distant bodies, independent stellar systems in different degrees of development, independent of our own stellar system.

Dr. Campbell concluded his address with the remark: "Working at peace and under extreme encouragement, the astronomers are learning the place of our star and its planets among other stars. If the spiral nebulæ prove to be separate and independent systems, we shall bequeath to our successors the mighty problem of finding the place of our own great stellar system amongst the host of stellar systems which stretch throughout endless space."

SCIENTIFIC ITEMS

WE record with regret the death of T. H. Bean, chief of the division of fish culture of the conservation commission of New York; of Clement Reid, F.R.S., late of the British Geological Survey; of A. M. Worthington, F.R.S., formerly professor of physics at the Royal Naval College, Greenwich, and of W. Ellis, F.R.S., formerly superintendent of the magnetical and meteorological department of the Greenwich Observatory.

AT the recent New York meeting of the American Association for the Advancement of Science Dr. Theodore W. Richards, director of the Wolcott Gibbs Memorial Laboratory, Harvard University, was elected to preside at the meeting to be held next year at Pittsburgh and to give the address the following year in Boston.

OTHER presidents of scientific societies elected at the recent meetings are Professor George H. Shull, professor of botany in Princeton University, of the American Society of Naturalists; Professor Frederic S. Lee, of Columbia University, of the American Physiological Society; Professor Robert M. Yerkes, of Harvard University, of the American Psychological Association, and Professor Frank D. Adams, of McGill University, of the Geological Society of America.

PROFESSOR M. I. PUPIN, of Columbia University, has been elected president of the New York Academy of Sciences, which in 1917 will celebrate its hundredth anniversary.—The Bruce gold medal of the Astronomical Society of the Pacific for the year 1917 has been awarded to Professor E. E. Barnard, of the Yerkes Observatory, for his distinguished services to astronomy.—Governor Whitman, of New York, has granted Dr. Hermann M. Biggs, state health commissioner, leave of absence to go to France, at the request of the Rockefeller Foundation, to conduct an organized campaign to combat the spread of tuberculosis among noncombatants.—Mr. Theodore Roosevelt made the principal address at the opening of the New York State Museum at Albany on the evening of December 29, his subject being "Productive Scientific Scholarship." The address was printed in the issue of *Science* for January 5. Among those who made addresses at the afternoon exercises were Dr. John H. Finley, president of the University of the State of New York; Dr. Charles D. Walcott, secretary of the Smithsonian Institution, and Dr. John M. Clarke, director of the State Museum.

THE Naples Table Association for Promoting Laboratory Research by Women announces the offer of the Ellen Richards Research Prize of $1,000 for the best thesis written by a woman embodying new observations and new conclusions based on independent laboratory research in biology (including psychology), chemistry or physics. Theses offered in competition must be in the hands of the chairman of the committee on the prize before February 25, 1917. Application blanks may be obtained from the secretary, Mrs. Ada Wing Mead, 283 Wayland Avenue, Providence, R. I. The Sarah Berliner Research Fellowship for Women of the value of $1,000 is offered annually, available for study and research in physics, chemistry or biology. Applicants must already hold the degree of doctor of philosophy or be similarly equipped for the work of further research. Applications must be received by the first of February of each year. Further information may be obtained from the chairman of the committee, Mrs. Christine Ladd-Franklin, 527 Cathedral Parkway, New York.

Vol. 4, No. 3 . MARCH, 1917

THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: SUB-STATION 84

SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION, $3.00

THE SCIENTIFIC MONTHLY

MARCH, 1917

THE ADOPTION OF THE METRIC SYSTEM IN THE UNITED STATES[1]

THE METRIC SYSTEM FROM THE STANDPOINT OF ELETRICAL ENGINEERING

BY ARTHUR E. KENNELLY, Sc.D., A.M.

PROFESSOR OF ELECTRICAL ENGINEERING, HARVARD UNIVERSITY AND MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IT is now generally admitted by the great majority of intelligent persons in America, that the metric system is a much simpler and better system than the customary Anglo-American system of weights and measures. Including all the units appearing in our regular American school lists of length, area, volume, dry measure, apothecaries' measure, liquid measure, cord measure, avoirdupois and troy weight, there are in vogue about forty units with numerous and miscellaneous numerical cross ratios; whereas the metric system employs only two—the meter and the gram, with derivatives, provided it be admitted that a decimal derivative is merely the same unit with a shift of the decimal place. Thus in the case of a sum of money expressed both in dollars and in cents, the cent may be considered to be included within the dollar unit. A considerable amount of our school arithmetic is occupied in learning tedious conversions from one measure to another, or from one unit to another unit of the same measure, all of which is saved and eliminated from the arithmetic of foreign countries.

Moreover, apart from the question of relative simplicity of the metric and Anglo-American systems, the fact is self-evident that the metric system is an international system, in the sense that all the accurate scientific work of the world is done in that system, in America or elsewhere, and also that it is the system used in every-day life by the civilized peoples all over the world, except in America, Great Britain, and her colonies. It is surely inevitable that when two systems of units, one clumsy, complex and crude, the other simple and scientific, are

[1] A conference held under the auspices of the Section of Social and Economic Science of the American Association for the Advancement of Science, New York, December 26, 1916.

operating side by side, the world is too small to permit of both being continued indefinitely. Sooner or later the complex system of one set of peoples must give way to the simple system of many sets of peoples, each of which has already thrown over its original system in favor of that simple system.

It appears, therefore, that the real question to be considered at this time, is not whether the Anglo-American system shall or shall not be indefinitely retained. That question was settled long ago, when all the other countries of the world came, one by one, to adopt the metric system. The real question is how, and how soon, the English-speaking peoples should change to the international metric system. Deferring the change does not make it any easier. The longer we put it off, the longer we cut ourselves off from full quantitative concourse with the rest of the civilized world, and the harder we make the exchange of ideas and the exchange of commodities. Already the English-speaking peoples are intellectually beleaguered by all the other peoples, who regard us in this matter as on a lower level of development. Our books and writings, in all quantitative statements of the customary system, are either neglected or ignored, on account of the difficulty of understanding them. Moreover, they are ambiguous even to ourselves; because the respective wet and dry American pint, quart and gallon differ from each other and from the corresponding British quantities, by a very considerable percentage, not to speak of the different kinds of pounds and tons; so that when we see any of these units in general literature, we often do not know which is meant.

The principal objection raised against the general introduction of the metric system is the expense which the change would involve. Some go so far as to assert that the change would necessitate the rejection and destruction of a large amount of machinery and machine tools throughout the country. There seems to be no warrant for the latter belief. In France, Germany, Italy and other countries which have adopted the metric system, the history of the change indicates that the only machines destroyed or put out of commission by the change were those which made the old measures. A machine for turning out foot-rules or pound weights would clearly call for considerable modification or even for rejection. Such special machines would, however, be relatively very few, and the new business involved in making the new measures would be likely to compensate for this loss. No ordinary machines, such as lathes, drills, shapers, etc., would have to be changed if the metric system were adopted: because no one would be likely to insist upon having things changed to exact even sizes in the new measurements. The same old tools would go on making the same old things; but the numerical values of the sizes made would be altered. At the present time, the sizes of parts are seldom exact unit sizes. They have

ordinarily to be expressed in units and decimals, especially when precision is required; so that, under the new system, there would be merely a recataloguing under new units and decimals. There would certainly be expense connected with the change; but it would be more of an intellectual character than of a material character. It would be essentially the expense of learning the new system, and of becoming familiar with it. It would be the expense of recataloguing, reestimating, altering the sizes of parcels and of purchases, together with the expense of the mistakes that would naturally occur during the transition period. An appreciable source of expense would lie in the translation of sizes and other recorded quantities in books, blueprints and general literature. All changes for the better involve some inconvenience and expense. The national and international advantages would, it is generally conceded, go far beyond defraying the necessary inconvenience and expense of changing the numerical scales and measures of the things which we use. It is not likely that this would involve any appreciable change in the things themselves.

The individuals most inconvenienced by the change would probably be the intellectually aged, who could not change their fixed habits of thought even into simpler channels, and those engaged in businesses involving numerous records, such as surveyors or manufacturers with large numbers of lists and drawings of sizes and parts. On the other hand, many classes of the community, such as merchants, professional men, farmers and manual workers, would have but little difficulty in their part of the transition.

The American Institute of Electrical Engineers took a canvass in 1902 of their membership, on the question of the adoption of the metric system by congress. A large majority were in favor of the change. Electrical units, which are international and in world-wide use, are already metric. That is to say the volt, ohm, ampere, etc., used in all electrical engineering are derived from and based on the metric system. The use of such units in connection with the Anglo-American units is made unnecessarily awkward, and a change to the metric system would simplify the use of electric units. All the monthly bills for electric lighting and power rendered from electric meter registrations in the United States are already metric. Every nickel or five-cent piece fresh from the mint, weighs just five grams by law. In these and a few other matters of daily life, we have already changed to the metric system in the United States.

In view of the inconvenience of a change in America to the metric system, no sudden transition should be invoked by congressional action. Ample time for preparation should be allowed in any legislation directed towards the change. In this way, lists, catalogues, and sizes could all be tabulated in advance in both systems, side by side, so that gradually

the old numerical values could be dropped. The easiest and least expensive way of introducing the system would probably be to have certain United States government departments adopt the system exclusively after a certain date. Only those persons or firms dealing directly with those departments would then be compelled to change their listings and prices. Gradually, the process would be likely to extend into general literature, business and manufacture, without the exercise of compulsion.

THE METRIC SYSTEM FROM THE PAN-AMERICAN STANDPOINT

By WILLIAM C. WELLS, LL.B.

CHIEF STATISTICIAN PAN-AMERICAN UNION, WASHINGTON, D. C.

THE Pan-American Union was created by a resolution adopted in the First International Conference of the American republics held in Washington in 1889. All the twenty-one independent republics of North and South America join together in the support and maintenance of the institution which is governed by a board consisting of the secretary of state, *ex officio,* and the diplomatic representatives in Washington of the twenty Latin American republics. Its general purpose is to create and foster a larger commercial and intellectual intercourse between the republics of the American continent. It is an all American institution interested in every question which does or might concern the two Americas, among which the question of weights and measures is not the least important.

If there is one thing in the future that can be predicted as a truth with more certainty than another it is the changing position of the United States in respect to its foreign commerce. This change, while it will be accelerated by the war, is in no way a result thereof. It is due entirely to our own development, consequently creating a changed international commercial status for the United States. It is industrial evolution in its comparative relations.

Formerly our exports were of raw materials, primary food products, slightly wrought commodities, in fact, of those things wherein the larger commercial values were represented by the work of nature and the lesser values by the work of man. We were selling primarily the minerals from our hills, the trees from our forests, and in our cotton and our grain the fertilizing elements of our soils. We were selling for the most part the handiwork of nature and not of man. We were depleting our capital resources—but on the whole not at a loss. We were following the natural highway of evolution from the forest and mining industries

to the pastoral, to the agricultural and on to the mechanical. In a sense we were converting a part of our static capital into liquid capital.

In the last decade or two the character of our exports has begun to change. Measured by values, we are selling less of the products of our mines, of our forests and of our fields and more of the products of our labor and skill. Where we sold lumber we are selling chairs, tables and desks, where we sold pig iron we are selling knives, plows and machinery.

It is not necessary to elaborate this idea. It must be apparent to every one that we are coming to the point where our growing population will consume all our own food products, where our mills and factories will use all our own raw materials and where our only surpluses for export will be the finished and highly wrought products of these mills and factories. This is as it should be, for thus we shall be selling for the most what man creates and for the least what nature creates. What has all this to do with the metric system? Much, very much.

Broadly speaking, all exports may be classed under two heads: First, such as sell themselves, that is, where the buying and selling machinery is for the most part put in operation by the buyer, and, second, such as must be sold; that is, where the machinery is operated almost entirely by the seller. These two classes correspond almost exactly with the two other classes first indicated above, viz., raw materials and primary food products, on the one hand, and finished and highly wrought commodities, on the other.

Cotton, wheat, flour, lumber, unwrought metals, oils, hides, wool, meat and the like sell themselves. Wherever in the world these things are needed and there is the price to pay, the buyer sets in operation the machinery to secure them. The farmer does not have to send out commercial travelers to sell his cotton. He does not have to advertise it in the papers. He delivers it to the railway and here it is caught up by a machine in no wise of his creation which finally dumps it down at some factory door, where, the farmer never knows; it may be in Massachusetts and it may be in Italy. But for the factory that spins the cotton into yarn and weaves the yarn into cloth it is another matter. This cloth does not sell itself. It must be sold and its maker must find a market for it. The impulse begins at the factory, it follows through the broker, the wholesaler, the retailer down to the ultimate consumer. Cloth, knives, plows and desks must be pushed from behind. They are not pulled from in front as is cotton, wheat and pig iron.

It is here that we come to the point where weights and measures are important. It is a matter of small or even no moment to the foreign purchaser of our wheat and cotton that as produced they were measured in bushels and pounds. These measures are not stamped upon the wheat, cotton, oil, iron, copper and the like. If he wishes to buy 1,000 metric quintals or 1,000 liters of any of these, it is a matter of no in-

terest to him that the producer in the United States measured the product by pounds, bushels or gallons. It is a matter of little interest that on the manifest of the ship that brought him these goods they were denoted by these measures. All this can be changed and is easily changed. Not so if the goods be shoes, cloth, screws, clothing, tools and machinery. Here the inch, the yard and the pound are wrought into the article as a part of its warp and its weft. He can not sell them, his customers will not buy them. What do they know of a 15½ collar or the No. 8 shoe? The shopkeepers can not sell the yard-wide cloth to people who are used to buying meter-wide cloth. The artisan who needs a 2½ centimeter chisel will not take an inch chisel instead. The man who needs a bolt or a nut threaded to the metric scale will not take such as are threaded to the inch scale. Nothing fits, nothing suits, and finally nothing is salable.

Our changing foreign trade demands a change in our customary measures. So long as we cling to our inches, yards, pounds and gallons we carry a weight, a useless weight, that of itself is sufficient to hold us back from that first place as an exporter of highly wrought manufactures which is ours by right of skill, enterprise and resources.

The importance of the metric scale in foreign commerce even now presses hard upon us, and it will press harder and yet harder in the future. We must adopt the metric scale, because nearly all the rest of the world, save England and Russia, has adopted it and this world is the market in which we must buy and sell.

Furthermore, we should adopt it because of its inherent merits, its vast superiority even for domestic use over our present system. I think I may say without fear of successful challenge that, while any intelligent child can learn and carry in his mind the whole metric system in three lessons and any adult can master the same in one hour or less of serious study, no man ever has, and probably no man ever will, master the United States system of weights and measures. Personally I would rather undertake to commit to memory the multiplication table up to the factor of 100 than undertake such a task as this. Take the case of bushels and barrels, measures upon which millions upon millions in values of products are bought and sold; there are scores upon scores of different bushels and hundreds upon hundreds of different barrels customary, standard and legal in use in the United States.

The metric system is simplicity itself. It has many merits in nomenclature in interchangeability from lengths to weight to volumes, but the chief merit to my mind is that it has the same base ratio throughout. Measures should have the same base ratio. That they have not is one of the principal inherent weaknesses of our English system as compared with the metric system. For example, suppose that our system had as its base 12—12 inches to the foot, 12 feet to the yard, 12 yards

to the rod, 12 rods to the mile; 12 drams to the ounce, 12 ounces to the pound, 12 pints to the quart, 12 quarts to the bushel and so on; then the superiority of the metric system with its base 10 would not be so apparent. This would be true even though there were no interrelation between inches, drams and pints. The interrelation in the metric system between meters, liters and grams is purely artificial. Its value is principally in the determination of the standards and not in their use. The important thing is the identity in base ratios. Were it not that we are not at the beginning of things, 12 would be a much better ratio than 10, because of the many aliquot factors in 12—2, 3, 4, 6. But neither 12, nor any other number than 10, can be made the base ratio, because measures of weights, lengths and capacities are bound up in the larger subject of numbers. Our system of numerical notation is based upon the ratio of 10. It might have been based upon 12 and would in all probability have been the better therefore, but it was not, and so our system of measures must likewise be based on 10. All the world counts by tens and most of the world measures its money by tens. Compare our money values, ten cents a dime, ten dimes a dollar, with English money having no constant ratio, four farthings a penny, twelve pence a shilling, twenty shillings a pound, not to mention five and twenty-one as the ratios of crowns and guineas, and one immediately sees the great advantage of ours over the English system. The child has to learn only one thing, viz., the progression of values, the ratio is constant. He is not in any danger of making the mistake often made by the English child of getting his twelves and his twenties mixed. But the real difficulty comes when the English child begins to put his values down on paper, when he begins to add, subtract, multiply and divide English money values. This difficulty lasts him through life. How many Americans off-hand can give the correct answer in pounds, shillings and pence to the simple problem of 100 units at 7½d. per unit? (£3 2s. 6d.) Yet every American can answer immediately the problem in dollars and cents of 100 units at 7½ cents.

One must be a little on the outside in order to get the right view. The facility with which the Englishman handles his twelves and his twenties does not detract from our wonder that he is able to do it, nor change our judgment that this facility represents an enormous waste of effort. So to the Frenchman or German our apparent ease in handling twos, fours, twelves, sixteens and thirty-twos, in pints, quarts, inches, ounces and bushels is a subject of wonder, but not of envy.

A mile has 8 furlongs, a furlong 40 rods, a rod 2¾ fathoms, a fathom 2 yards, a yard 3 feet, a foot 12 inches and an inch 3 barley corns. A ton has 20 cwt., a hundred weight has 100 lbs.—unless it be a long ton and then it has 112 lbs.—a pound has 16 ounces—unless it be a troy pound—an ounce has 16 drams and a dram has $27^{11}/_{32}$ grains. This is all as wonderful as a cubist painting.

Nevertheless, we can be of good cheer. There is worse to come. A Frenchman, a German or a Brazilian has one quart—he calls it a liter and it is the same in France, in Germany and in Brazil. We have two quarts, the wet and the dry. One of them is smaller than the liter and the other is larger. Our housewives must measure their molasses and vinegar in the one and their flour and beans in the other, otherwise the domestic economy goes all awry.

Pints, quarts, gallons and bushels are an inheritance from Great Britain, the British wine gallon being the basis of our wet measures and the Winchester bushel of our dry. But the British have discarded both, and adopted a new and larger standard gallon and bushel. So 50 gallons doesn't seem to mean much of anything unless one knows whether it is whiskey or walnuts, American or English. But the term bushel is used commercially in two senses, as a measure of volume and as a conventional weight. The two are supposed to be interchangeable and are so considered, but they are not. The farmer measures his grain by volume, the buyer by weight. The volume bushel is standard, the same in every state, but the weight bushel, the bushel of larger commerce, is not. Wheat is 60 lbs. everywhere. Rye is 56 lbs. in most states, but is 54 in California and 50 in Maine. Barley is 48 lbs. in the larger number of states, but is 45 in Arizona, 46 in Oregon, 47 in Pennsylvania, Kentucky, Georgia and Alabama, and is 50 in California. Buckwheat is 40 lbs. in California, 42 in N. Dakota, S. Dakota, Oregon and Washington, 48 in nine states, 50 in seven, 52 in eleven and 56 in Kentucky. Shelled corn may be anywhere from 50 to 58 lbs. and corn in the ear may vary by law according to the month in which it is weighed. One of the most familiar units of commercial measure is the barrel. Apples, potatoes, vegetables generally, flour, lime, crude oil, cement and dozens of other commodities are customarily bought and sold by the barrel. For farm produce the measure is ordinarily one of volume, for flour, lime, etc., it is of weight based on volume. It is important to know what is the size of the base barrel. There is no such thing. A bushel by size is standard, but there is no standard barrel or rather there are hundreds of standards. The result is that we have all the difficulties of the bushel multiplied scores of times over.

One could pursue this vein through many channels and everywhere the same condition is met, confusion and uncertainty, entailing commercial loss and inefficiency. Applied to foreign commerce the whole mass of incongruities known as the American system of weights and measures is impossible. But we are told that we can not change it, that it is too firmly fixed. I doubt this.

There are certain manufacturing industries whose tool equipment, upon the inch and foot gauge, can not be adjusted to the meter gauge, but these are very few. Most tools can be adjusted at but little cost.

For the rest the change here would be easy as it has proved easy in every country which has adopted the metric system. This statement is sometimes denied. The denial, however, is based upon a confusion of ideas. It has been found somewhat difficult in countries adopting the metric scale to do away with the names of the most used measures, such as yards, quarts, pounds, miles, etc., or rather of the equivalents of these English words in the language of the country adopting the new system. Pound, libra, livre, pfund, etc., was an almost universal measure. Not always the same, of course, but in most cases very nearly the same. Now in substituting kilogram for pound, it has been found that people were slow to substitute the new word. Take all the various pounds of France, the German states (all different), Austria, Hungary, Scandinavia, Italy, Spain, etc., in general the kilogram was two pounds or a little over. What happened? The people kept the word, but applied it to a half kilogram, 500 grams. So we have at present the pfund in Germany, which is not at all the old Hanoverian, Saxon or Bavarian pfund, but is 500 grams. So likewise we have the libra in many Latin American countries, but it is not the old Spanish libra; it is, as in Germany, the half kilo.

It has been found very easy to substitute the thing, although sometimes difficult to substitute the word. It is the thing that we who advocate the metric system desire, the word is of less importance. It matters but little if having the meter we continue to use the word yard. The important thing is that it be of meter length and divided decimally. I can remember in my childhood that people spoke of shillings and pence—ninepence, two and threepence, shilling, fourpence halfpenny. Strangers might have thought that a hundred years after the adoption of the dollar standard folks in Virginia were yet using English money to count with. Nothing of the kind. The words were an English inheritance, but the thing itself was of pure American invention, and its basis was a dollar divided in six parts—eight in New York. Two and threepence was 37½ cents and fourpence halfpenny was 6¼ cents. These values were approximately two thirds of English values and in New York but little over one half.

Scarcely a vestige of the old standard is left in any country that has adopted the metric system. Now and then in Latin American countries one will hear the old words, but almost always with a meaning adapted to the new scale. Sometimes apparently the old measure is kept. Thus, in Chile in the nitrate industry apparently they keep the old Spanish quintal, 100 Spanish pounds, a little over 101 lbs. avoirdupois. This seemed curious to me, the more so since all Chilean statistical reports give weights of nitrate in the metric scale. When I was last in northern Chile I enquired into this and found that there was not a weighing machine in all the nitrate fields graduated to the old Spanish

scale. They used the metric scale, but they measured 46 kilograms to the quintal, and 46 kilograms is not exactly the old quintal.

That we must, and furthermore that we shall, come to the metric system is to my mind beyond question. First, because the exigencies of our foreign trade make it impossible for us to do otherwise, and second, because the present system is too cumbersome, too uncertain, too complicated and too difficult to learn even for our domestic uses. At the present time one may discern evidences of senility and breaking down in the constant and increasing multiplication of standards. Almost every fruit and vegetable now has its own container and these containers are becoming the customary and in many cases the legal standard of measure in purchase and sale.

We can not help ourselves in the foreign trade, for there we must come to the metric system. It is, of course, quite possible to have two systems, such as, in fact, exist in England to-day, and even in this country, although in a lesser degree. English manufacturers engaged in foreign trade work almost exclusively in the metric scale. In some cases English factories work in two scales, one for the foreign and one for the domestic trade. In the United States we are coming to the same condition.

The United States, Great Britain and Russia are almost the only countries now outside the fold of the metric system. Russia is only nominally outside, for nearly all Russian mechanical industry and the overwhelming proportion of its foreign trade is unchangeably based on the metric system. Prior to the war Great Britain had for practical purposes adopted the metric system in manufactures for foreign trade. Since the war the metric system has extended into other fields of commerce even into the domestic trade. In the United States the progress has been less rapid, but our factories have turned out enormous supplies of war material manufactured to the metric scale, and to-day thousands upon thousands of our workmen are as familiar with centimeters and grams as they were formerly familiar with inches and ounces.

THE METRIC SYSTEM IN EVERY-DAY LIFE

BY PROFESSOR H. V. ARNY, PH.D.

COLUMBIA UNIVERSITY

THERE seems but little that I can add to the admirable addresses delivered by the distinguished men who have just presented their views. In fact, all I can do is to present a simple story of my own experiences with that beautiful, logical and simple system of weights and measures now used by 437,000,000 of the people of this globe.

In school, as a twelve-year-old youngster, along with other monstrosities such as cube root, proportions involving the wildly exciting facts that if ten men in seven days could excavate a ditch 1,000 feet long; then three men in twelve days could excavate X feet of trenches, I learned that there was a foreign thing called the metric system; that it dealt with "decis" and "centis" and "kilos" and "millis" and "dekas"; that the thing they called the kilogram represented 2.2046 pounds, that the kilometer was 0.6213 miles. These data passed through the mind of the lad and along with cube root were shortly consigned by him to the limbo of uninteresting and unnecessary things.

Later, as a pharmaceutical apprentice, I learned that this self-same metric system was used by the French physicians of the neighborhood in writing their prescriptions and there then came the first intimation that metric weights were of some practical use. Later in college, all pharmaceutical preparations were prepared by metric units and a month of use of such weights and measures brought a realization that their decimal subdivisions made them as superior to the ordinary units of weights and measures as dollars and cents are easier to calculate than are pounds, shillings and pence.

Later, four years' residence in Germany completed my metric conversion. In truth it might be stated that the first week did the work, since any one accustomed to our decimal system of currency finds that *thinking* in the metric system is merely the matter of *using* the units. In using the meter, one learns that it approximates the yard; in using the kilogram, the novice instinctively thinks of two pounds; in discussing distance in kilometers, one quickly comes to the realization that the unit means about five eighths of a mile. And after a few weeks of such mental translating, one drops all thought of old units and thinks of quantities exclusively in kilos and meters.

Despite assertions to the contrary, I found in Germany, barely twenty-five years after the official adoption by that country of the metric system, that all purchases I made were on the basis of the metric system. It is true that in the market places, the peasants talk of "Pfunds" (pounds), but it is equally true that their "Pfund" is the official half-kilo weight. Nor do we have to cross the ocean to find such anachronisms. In certain sections of this land we hear the silver quarter called the shilling; in other parts of the land it is called "two-bits"; while it is an undeniable fact that in one city the five-cent piece is still called to a certain extent "the picayune," after a Spanish coin of six and a quarter cents value, that was used in that section a century ago. Nor do I believe that these colloquialisms prove the failure of our decimal system of currency.

The only justification for the adoption of the metric units as the official standard of this country is: (*a*) The development of our foreign

trade demands the change. (*b*) The saving of time brought about by the use of the metric system would repay the annoyance incidental upon the change.

The first proviso has been emphatically answered by the speakers who have preceded me; but I can add some testimony as to the time-saving properties of the system.

As to this there have been a number of extravagant statements made by metric enthusiasts, but figures founded on experimental work have been rare. Accordingly a comparative test of the same problems expressed in United States and metric units was made on third-year university students by having them solve the following commercial problems.

In order to eliminate the problem of fatigue, half of the students were given the metric, the other half were given the United States problems first.

As to the problems themselves, the first four are ordinary transactions of retail trade. All eight of these (United States and also metric) could be calculated within three minutes and while metric units showed an advantage, it was so slight that the difference could be expressed only in seconds. The next two of each set involve practical problems of the chemical industry where liquids bought by the pound frequently are dispensed in gallons. The last problem is taken from the *Outlook* of November 16, 1916, where the author of an article published in a previous issue apologized for an error made in calculating the cubical capacity of the eight billion dollars claimed to represent the gold coin of the world. He acknowledged that while his article stated that eight billion dollars represented a cube of gold seventy feet on each side, the real figures were a cube of twenty-nine feet, or 25,641 cubic feet.

If a distinguished financial publicist could make such an error, I was curious to see what a class of students could do with it in both systems. The figures below show that the honors were even, although it is only fair to say that in the metric problem two were ruled out because of the improper placing of the decimal point.

The results of the experiments are tabulated below.

PROBLEMS BASED ON METRIC UNITS

1. Cost of 22 tubes of tooth paste at $1.45 a "dizaine" (a package of 10).
2. Cost of 2.26 kilos of quinine sulphate at 4.7 cents a gram.
3. Cost of 27 kilos of coal at $7.70 a metric ton (1,000 kilos).
4. Cost of 1.7 meters of cloth at 26 cents a meter.
5. Cost of 7.27 liters of glycerin (sp. gr. 1.25) at 44 cents a kilo.
6. Cost of 5 liters of sulphuric acid (sp. gr. 1.84) at 22 cents a kilo.
7. A gold dollar contains 1.67 gm. gold. How many meters of gold (sp. gr. 19) would represent eight billion dollars?

Problems Based on Ordinary (United States) Units

1. Cost of 22 tubes of tooth paste at $1.75 a dozen.
2. Cost of 5 lbs. (avoirdupois) of quinine at $1.45 an avoirdupois ounce.
3. Cost of 59 lbs. of coal at $7.00 a ton.
4. Cost of 70 inches of cloth at 24 cents a yard.
5. Cost of two gallons of glycerin (sp. gr. 1.25) at 20 cents an avoirdupois lb.
6. Cost of 1⅜ gallons sulphuric acid (sp. gr. 1.84) at 10 cents an avoirdupois pound.
7. A gold dollar weighs 25.8 grains. How many cubic feet of gold (sp. gr. 19) would represent eight billion dollars?

Results of the Test

On Group I

Student	Metric		U. S. Measures	
	Time	Correct Out of Six	Time	Correct Out of Six
A	15 minutes	5	21 minutes	4
B	13 "	3	18 "	4
C	11 "	6	18 "	5
D	15 "	1	14 "	3
E	18 "	2	13 "	3
F	10 "	4	23 "	5
G	8 "	6	16 "	5
H	8 "	4	10 "	3
I	12 "	6	22 "	4
J	7 "	3	16 "	3
K	8 "	6	13 "	6
L	9 "	4	18 "	3
M	24 "	4	12 "	1
N	13 "	3	13 "	3
	171 minutes	68%	227 minutes	62%

Results of the Test

On Group II

Student	Metric		U. S. Measures	
	Time	Correct Out of 7	Time	Correct Out of 7
A	19 minutes	5	42 minutes	6
B	30 "	4	36 "	5
C	25 "	4	39 "	5
D	19 "	5	26 "	4
E	23 "	5	28 "	5
F	21 "	6	47 "	4
G	26 "	6	33 "	2
H	24 "	2	42 "	1
I	30 "	5	37 "	5
J	22 "	7	27 "	6
K	20 "	4	54 "	3
L	14 "	7	27 "	5
M	28 "	3	30 "	5
N	15 "	6	35 "	7
O	22 "	6	37 "	4
P	22 "	6	39 "	6
	360 minutes	72%	579 minutes	65%

The figures just given show that one class of third-year university students did the first six problems in United States units in 227 minutes, the similar metric problems took only 171 minutes; that, while a second group did all seven problems in United States units in 579 minutes, they took only 360 minutes to do the same problems in metric units. It will also be noticed that the percentage of correct problems in the metric system is somewhat higher than those done with United States units; hence the metric system is not only a tremendous time-saver, but gives in the hands of the average student more accurate results.

Enough, I think, has been said about the advantages of the metric system. Our presence here to-day attests to our belief that we should in the due course of time become a metric country. And now that we have come together, what are we going to do? It would be the worst of blunders if we, representing such diversified occupations, should not, before we separate, form a permanent organization aimed to disseminate the metric gospel among other commercial bodies until they too agree with us that it is high time for this country of ours to throw off the shackles of an Elizabethan set of standards and add our 110,000,000 people to the 437,000,000 already using the metric system.

THE METRIC SYSTEM FROM THE STANDPOINT OF THE WHOLESALE GROCERS AND CANNING INDUSTRY

By FRED. R. DRAKE

EASTON, PA.

THE National Wholesale Grocers Association of the United States, with eleven hundred members in the forty-eight states of the Union, is now in its eleventh year and was organized at Buffalo in 1906 to advance the welfare of the wholesale grocery trade.

In 1912 at our St. Louis convention we began a campaign of education on the metric system looking to its eventual compulsory adoption by congressional enactment as soon as the electorate could be educated to a knowledge of its desirability.

This work has been carried on under the direction of our pure food and legislative committee by a subcommittee on metric system. Of this latter committee I have had the honor and pleasure of being chairman.

In 1912 many of our members were not fully informed as to the exact status of the metric system in the United States and before beginning our campaign of education, our committee undertook an exhaustive examination of literature on the subject as well as an investigation of

the practical working of the system in the countries which had adopted it. It is doubtless known to many of you that a mere bibliography of the metric system would make an ordinary volume.

This investigation of our committee, of works unfavorable as well as favorable to the system, led us to get enthusiastically back of an educational propaganda favorable to its eventual compulsory adoption and this we have kept up by every means at our limited disposal.

Our executive committee strongly supported our metric committee, and our association, in annual meeting assembled each year, has reaffirmed its position favorable to its adoption for all purposes in the United States.

I believe it is true that while scientific bodies for over forty years have passed resolutions favorable to the adoption of the metric system, the National Wholesale Grocers Association was the first commercial body of national proportions to openly advocate its use and compulsory adoption for all purposes.

Our committee prepared and made addresses before meetings of Wholesale Grocers Associations in the different states and where impossible to appear ourselves, we had the subject presented and explained to the committees on resolutions and resolutions favorable to our campaign were presented and adopted.

The Retail Grocers Association of the United States has passed resolutions favorable to our work; many retail grocers are foreign born and were educated at home in the metric system and they are enthusiastically in favor of its adoption here by reason of its known simplicity to them. This is true of many wholesale grocers also.

In addition our campaign has been endorsed by the Wholesale Grocers Associations of New England, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Ohio, Indiana, Michigan, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Nebraska, Kansas, North Dakota, Colorado, New Mexico, Arizona, California and Oregon; by the National Conference of Food, Dairy and Drug Officials; the National Conference on Weights and Measures for the United States; the National Canners Association and by a number of your affiliated scientific societies.

I am trying, however, to bring you trade information that ordinarily would not come to you as scientific men.

In 1913 our committee visited the International Bureau of Weights and Measures at Sèvres, France, and had a very interesting conference with Dr. Benoit, the director, and since that time has been exchanging publications with them as well as with the Decimal Association of Great Britain, advocating the metric system there.

We have reprinted and distributed to our members a number of addresses and articles, and furnished the Decimal Association of Great

Britain 3,000 of our reprints of the article on the metric system that appeared November, 1914, in the "Nation's Business," published monthly by the Chamber of Commerce of the United States.

At our Minneapolis meeting in 1914 we passed the following resolution:

With the idea of familiarizing the consumer with the metric system, we urge all our members to request manufacturers with whom they deal to use the metric equivalents on all new labels, in addition to the English weights and measures, and urge our members to follow the same practise where they are using labels on their private brands as permitted under Food Inspection Decision No. 154, which reads: "Provided that by like method such statements may be in terms of metric weight or measure," believing that the constant sight of the metric equivalents on food products in the millions of homes where they go, will have great influence toward awakening interest in, and educating the consumer to a better knowledge of the metric system.

Following the issue of food Inspection Decision No. 163, early in this year, our committee last March issued a letter to our members enclosing a card of metric equivalents in connection with the weights of canned goods in the English system, and also circular No. 47 published by the Bureau of Standards containing tables of equivalents capable of converting every possible avoirdupois weight or English measure into its metric equivalent and vice versa, together with full explanation of its use. In addition we distributed to our members at the same time Senate Document No. 241 containing the report prepared by Dr. Samuel W. Stratton, Director of the Bureau of Standards, at the request of the Secretary of the Treasury, Mr. McAdoo, for the use of the International High Commission on uniformity of laws. This report relates to the metric system in export trade, but has proved to be one of the most interesting contributions to metric literature of the year.

Interest in the label question referred to above is not confined to wholesale grocers. We have taken this matter up with the American Specialty Manufacturers Association in our conference with them and are receiving requests for our canned goods equivalents list sent out with our March letter. The secretary of the National Canners Association, Mr. Frank E. Gorrell, has advised us that their association will cooperate with us on the label question in consonance with their attitude favorable to our campaign of education on the metric system. The use of the metric system in the last edition of the United States Pharmacopeia is one more step in advance in the eventual general use of the metric system in the United States.

Since our campaign opened many advances have been made. The international carat standardized at 200 milligrams, replacing the many valued, highly ambiguous "carat" heretofore used in many lands, is one of them. The present war in Europe and American world trade expansion has helped the metric propaganda by years undoubtedly.

The contact of England and her colonies with the Allies is bound to have its effect on not only the officers and men, but the government at home, and the unity of action in war is bound to have its effect after peace is declared. England is showing many signs of giving up her arbitrary attitude in world trade and this is shown to be more necessary as the war progresses.

We believe that the adoption of the metric system by Germany, embodying, as it did, the casting aside of many traditions for the sake of efficiency, had a great deal to do with the wonderful success of Germany as a world commercial power. The change at the time she made it was a much more radical one for Germany than the change for the United States would be now, for we are already using it in many branches of the government service, including now, aeronautics, as well as in scientific lines and commercial life.

We believe it is not generally realized by the public that the federal government has enacted practically no weights and measures legislation, but has left the question entirely to the states. Even the pound, yard, gallon and bushel have never been adopted by congress, but owe their standing to the fact that the government uses them in the collection of revenue and to the fact that they have voluntairly been adopted by the states. Just as was the National Pure Food and Drugs Act of 1906 with its amendments necessary to harmonize and make effective legislation on food and drugs, so is there necessity for a National Weights and Measures Law. The National Wholesale Grocers Association believes the system of weights and measures enacted into law should be the International Metric System in simplification not only of our international transactions now grown so enormous, but of our wonderful interstate commerce, where the amount of time, labor and annoyance saved would be almost incalculable.

We are entering into no great argument with this audience with regard to the merits of the metric system, as we felt sure this would be more ably done by others than we could do it; however, we venture to assert and feel assured from our own experience that the change would make no greater charge on or disturbance of business than has food legislation during the past ten years and certainly nothing like as much care and anxiety. This is the fiftieth anniversary year of its legalization by the thirty-ninth congress in 1866. France was just about fifty years in making it compulsory there. It is time for the United States to make it compulsory here.

In conclusion, to quote from our committee's last annual report adopted by the tenth annual meeting held in Boston last June,

> We reiterate, that the attitude of the National Wholesale Grocers Association of the United States is that if there is a better system of weights and measures than we are using we want to know about it, and further, we believe that the

metric system is a better system than the one we have, and knowing there is something better, we want to see its adoption made compulsory by congressional enactment at just the earliest moment commensurate with the demands of the electorate educated to its real value.

We urge the approval of the formation of an association whose object shall be to forward the metric system propaganda in the United States by both educational and legislative means and favor giving such an association our active, moral and financial support.

WHOLESALE DRUGGISTS AND THE METRIC SYSTEM

BY ADOLPH W. MILLER, M.D.

OF THE NATIONAL WHOLESALE DRUGGISTS ASSOCIATION OF THE UNITED STATES, PHILADELPHIA, PA.

ALL radical changes in old, established and well-known methods of conducting business are invariably looked upon with great disfavor. It can not be denied that alterations in the units of weights, measures of length and capacity, will cause some trouble and no little expense. New moulds for bottles, new packages, new labels and a radical change in prices will become necessary. All these troubles taken collectively may not be much greater than those that have been inflicted upon the druggists in recent years by the fatherly supervision of the officials in charge of the food and drug act. In addition to this, when the changes of the metric system have once been effected, they will not be subject to whimsical alterations, but they will then permanently conform to the established standards.

The well-known advantages of the metric system are its simplicity, its uniformity, its decimal characters, the convenient convertibility of one unit to another, the clear manner in which its nomenclature expresses exact values, and the security of its unalterable base.

The simplicity consists in there being only five units in the entire metric system, of which only three are used by druggists, namely,

The meter, or measure of length,
The liter, or measure of capacity,
The gram, or measure of weight.

Larger and smaller quantities are expressed by seven prefixes to these terms. Of these the Latin prefixes deci, centi and milli divide the unit, while the Greek prefixes deka, hekto, kilo and myria multiply the unit by the number indicated.

Thus, a milligram is 1/1,000 of a gram, equal to about 1/65 grain,
a centigram is 1/100 of a gram, equal to about 1/7 grain,
a decigram is 1/10 of a gram, equal to about 1 1/2 grains,
a gram is equal to about 15 1/2 grains.

a dekagram equals 10 grams,
a hektogram equals 100 grams,
a kilogram is 1,000 grams, equivalent to about 2 1/5 avoirdupois pounds,
a myriagram equals 10,000 grams.

These equivalents are not strictly correct, but they are quite near enough for commercial purposes, and they are very much easier to remember than the exact decimal figures.

The above seven prefixes are likewise used for the liter and the meter, which they divide or multiply in precisely the same manner. The entire metrical system is therefore included in ten words, or, when the units of superficial area and cubical contents are added, in twelve words.

A rough and ready method of converting the most frequently used commercial unit into avoirdupois pounds is to multiply the number of kilograms by two, and then add ten per cent. Conversely, avoirdupois pounds can be changed to kilograms by dividing the number of pounds by 2.2. In the same manner, when quotations are asked for in kilograms it is only necessary to double the pound price, and then to add ten per cent. or to multiply the price at once by 2.2. For small quantities, only the gram is used as a unit. Although the actual equivalent of this is 15.432 grains, for practical purposes the decimal fraction may be dropped, so that then 4 grams will be equal to 1 drachm of apothecaries' weight.

In the writing of prescriptions in the metric system all the weights are expressed by Arabic numbers. No abbreviations are required, as the gram is always understood to be the only unit. Quantities less than a gram are written as decimal fractions. A vertical line is often printed on prescription blanks, so that whole numbers may be written on the left of this line, while decimal fractions are written on the right. In the absence of the printed line, the position of the decimal point can be clearly indicated by placing a "0" on the side where no figures appear.

The liter is the equivalent of a cubic decimeter. When filled with distilled water at its maximum density, it will contain 1,000 grams or a kilogram. Used as a measure of capacity, this is nearly 6 per cent. larger than the United States liquid quart. Our liquid measures can, therefore, be readily converted into metric measures by reducing them to quarts and adding 6 per cent.

The meter or unit of length is equivalent to 39.37 inches, being between 9 and 10 per cent. longer than our yard. The decimeter, or $\frac{1}{10}$ meter, a measure frequently used in botanical descriptions, is therefore almost equal to 4 inches. The centimeter has become quite familiar to druggists by the numbers used for French filters, which indicate their diameter in centimeters. One inch is very nearly equal to $2\frac{1}{2}$ centimeters, so that a No. 25 French Filter will have a diameter of

10 inches. The kilometer, or 1,000 meters, is nearly equal to $\frac{5}{8}$ of a mile.

The United States mints furnish very convenient metric weights in the shape of the dime, which weighs $2\frac{1}{2}$ grams, the 25-cent piece, which weighs $6\frac{1}{4}$ grams, the half-dollar, which weighs $12\frac{1}{2}$ grams and the nickel 5-cent piece, which weighs 5 grams and has a diameter of 2 centimeters.

As the metric system has been officially adopted and commercially used for many years in very nearly all civilized countries, except those in which the English language is spoken, almost all importers are already quite familiar with its various units, and with the most convenient method of converting them to our standards.

At the present time our manufacturers and exporters are seriously handicapped by their adherence to systems of weights and measures which have long since become obsolete among the more progressive nations. It would seem as though we were paying a heavy penalty for our slavish following of the bad example of England, which still demands that all the rest of the world shall bow down to her narrow insular prejudices. According to a pamphlet published by John W. Nystrom, C.E., England was about four hundred years behind the continental nations in the introduction of our present Arabic digits. He quotes many of the most absurd and truly ludicrous objections which were urged in England against the change from the clumsy Roman notations to the now universally employed Arabic decimal figures.

Quite a number of the more progressive German exporters have partly solved the problem by issuing price lists, in which English weights are quoted in both pounds, shillings and pence, as well as in dollars and cents, while on other price lists metric kilograms are quoted in francs, lires, pesos or marks.

John Quincy Adams fully recognized the supreme importance of simplifying the science of metrology, concerning which he said:

> Uniformity of weights and measures, permanent universal uniformity adapted to the nature of things, would be a blessing of such transcendent magnitude that, if there existed on earth a combination of power and will adequate to accomplish the result by the energy of a single act, the being who should exercise it would be among the greatest benefactors of the human race. . . . The French system embraces all the great and important principles of uniformity, which can be applied to weights and measures. . . . It is a system adapted by the highest efforts of human science, ingenuity and skill, to the common purposes of all. Considered merely as a labor-saving machine, it is a new power offered to man, incomparably greater than that which he has acquired by the agency, which he has given to steam. It is in design the greatest *invention* of human ingenuity since that of printing. . . . Its universal establishment would be a universal blessing.

In reference to the nomenclature of the metric system, Charles Sumner said:

A system intended for universal adoption must discard all local or national terms. The prefixes employed are equally intelligible in all countries. They are no more French than they are English or German. They are in their nature cosmopolitan and in all countries they are equally suggestive in disclosing the denomination of the measure. They combine the peculiar advantages of a universal name and a definition. . . . The name instantly suggests the measure with exquisite precision. . . . An afternoon would suffice to make the metric system plain to a class of school boys.

Superintendent Philbrick, of the Boston Schools, writes:

Of all the great problems bearing on the progress of civilization, which have in recent times engaged the attention of legislators and men of science, few are more important or far-reaching than that of the unification of weights and measures. To the speedy and complete solution of this problem of universal interest every community is bound to contribute according to its circumstances and ability. The grand aim of the metrological reform is comprised in three words, *uniformity, permanency* and *universality;* one standard to be the same for all persons and all purposes, and to continue the same forever. . . . A universal system of metrology should possess the following four characters:

1. Its base-unit should be a common measure of all its derivative units.
2. Its derivative units should increase and decrease by the decimal scale.
3. Its denominations should be expressed by convenient, definite and significant terms.
4. Its standard unit should be invariable and indestructible or reproducible.

This ideal perfection exists in the metric system, which France, acting as the representative of mankind, has invented and offered as a benefaction to the acceptance of all nations.

In conclusion it may be well to call attention to the prototype of the metric system, the one that we are using hourly, namely, our United States coinage of mills, dimes, dollars and eagles, all of them having the exact decimal relation to each other as the units of the French metric system. Without a doubt, when our business men have familiarized themselves with the terms and relative values of the metric system, they will find it to be just as infinitely superior to the perplexing English tables of weights and measures, as our convenient decimal dollars and cents are superior to the troublesome pounds, shillings, pence and farthings. Our successors will then express no little surprise that the druggists of the United States did not fully adopt the metric system for more than a century after its invention in France.

Joseph W. England, in a paper recently published by him in the *Journal* of the American Pharmaceutical Association, gives that which is probably the most practical advice of all to the druggists, both wholesale and retail, in the terse and pithy remark, that the proper and only way of introducing the metric system into this country is to stop lecturing, writing or talking about it, and at once begin actually to use it in the purchase and sales of drugs, in the manufacture of pharmaceu-

tical preparations and chemicals, in the compounding of prescriptions, and in the export and import of drugs and other commodities.

In still more forcible language, Dr. A. L. Benedict, of Buffalo, in the *New York Medical Journal* of April 29, 1916, calls for "the prompt and universal adoption of the metric system, at the cost of temporary inconvenience and contrary to habit, of something that is ultimately desirable and economic."

Even England is at last beginning to recognize the fact that the retention of the antiquated weights and measures will act as an obstacle to her trade in the future. Xrayser, in *The Chemist and Druggist* of May 13, 1916, says:

> Not till our purchases are made by metric system of weights and measures shall we really become so familiar with the metric system as to introduce it in sales. In view of the future of our *world trade*, the sooner we adopt the system throughout, the better for us.

Professor E. G. Eberle, in a very able article in the July, 1916, number of the *Journal* of the American Pharmaceutical Association, expresses himself thus:

> The attempt at aligning this system with the old should be discouraged in every possible way, because this one is not developed from the other. Think in the metric system, weigh and measure the quantities with the metric weights and measures, and very soon the senses of seeing, hearing and feeling will do their part, without noticeable effort of the mind. By this is meant, that seeing the written denomination, or hearing it spoken, the volume or weight will at once be associated therewith; just as is the case with those who are now experienced in the old system and who lack the same familiarity with the metric.

Inasmuch as two of our legal standards, namely, the United States Pharmacopoeia and the National Formulary make use of the metric system exclusively, the members of the National Wholesale Druggists Association should certainly be leaders in the movement for the universal and exclusive use of metric weights and measures. Nothing would do more to stimulate its employment among retail druggists than to compel them to purchase their supplies in this manner, so as to gradually abandon altogether the present custom of purchasing drugs by avoirdupois weights, compounding prescriptions by troy weights and wine measures, and making up official preparations, by still another standard.

THE INTERNATIONAL LANGUAGE OF WEIGHTS AND MEASURES

BY DR. GEORGE F. KUNZ
NEW YORK CITY

HOW difficult it sometimes is to make practise conform to theory has long been and still is shown by the continued opposition, active or passive, to the general introduction of the metric system into the United States and England. There can, indeed, be little doubt that so progressive a land as our own would long since have cast off the burden of the old scale of weights and measures, were it not for the fact that Great Britain, with which our commercial relations are so closely knit, still clings persistently to the so-called English weights and measures. On the other hand, could we pluck up courage enough to take the first step, England would most likely follow our lead after a shorter or longer interval.

Of the great advantages the metric system possesses in simplifying all necessary calculations regarding dimensions, there can be no question. Hence the opponents of its introduction here base their arguments mainly upon the difficulties involved in a readjustment of the various mechanical appliances of manufacture to a radically different scale. However, in many cases this difficulty is more apparent than real, and would merely imply a remarking in accord with the metric equivalent of the old measures, and the actual expense and very temporary inconvenience involved would assuredly be many times remunerated by the great advantages secured.

The first definite proposal for legislation to establish the basic principle of the metric system was made by as thoroughly practical a man as the great diplomatist Talleyrand, who in 1790 brought forward a measure in the French Assembly directing that a new unit of measurement should be established, based on the length of a pendulum beating seconds on latitude 45°; the selection of a pendulum beating seconds as a standard dates back, however, to Picard in 1671 and to Huygens in 1673. While this proposition of Talleyrand paved the way for the elaboration of the metric system, the details of the plan as worked out by the mathematicians Borda, Lagrange, Laplace, Condorcet and Monge, provided for the determination of the exact length of the quadrant of a meridian. Eventually, the ten-millionth part of this became the unit of length, and was denominated "mètre." In 1791 the Assembly sanctioned the measurement of an arc of ten degrees on the meridian of Paris, and as a result of seven years' work by Delambre and Méchain, this task was successfully accomplished.

The weight of a cubic decimeter of distilled water, divided by 1,000,

gave the unit of weight, the "gram," and the contents of a vessel of such dimensions constituted the "litre." From August 1, 1793, the metric standard has been the only one recognized in France and it has since been adopted by almost all the countries of Europe and America, excepting England and the United States, although it received legal recognition here July 27, 1866.

For the effective development of our foreign trade, for the utilization of the great and unique opportunities in this direction that the world war has given and will give us, it is most urgent that all foreign catalogues and publications issued by our manufacturers should have all dimensions expressed in metric as well as in English weights and measures. This can be done by placing the metric equivalents in parentheses. No better object lesson of the superiority of the metric system could be desired than that which would be afforded in this way, as its uniformity and simplicity would thus be brought directly home to every one who consulted the figures.

One notable result of the great demand for war material in this country from the European nations has been the enforced introduction of metric measurements in a large number of the factories devoted to such manufacture. This not only refers to guns, rifles, shells, etc., but also to locomotives, rails, parts of bridges, many tools and pieces of machinery, etc. The increased demand for our goods from South America, and the movement among our manufacturers to take advantage of the check of European exports to South America in order to introduce our productions there more widely and more consistently, works in the same direction. For our manufacturers are slowly learning the important lesson that if we wish to increase our trade in foreign lands we must endeavor to conform to the standards and usages current therein. When the war is over great opportunities will present themselves; but we must prepare now with a universal language of weights and measures.

England and the United States are slow in realizing the waste of time and the chances of error involved in translating the terms of a logical and consistent standard of weights and measures into those which only owe their use to a blind maintenance of tradition. For this reason those of us who favor the widest possible use of the metric system, not merely because this system is in force in all parts of Europe and America except England and our own country, but because of its inherent merits, must welcome every step taken in what we regard as the right direction for the attainment of what would prove a most potent factor in international trade, especially in Pan-America. Hon. William C. Redfield, Secretary of the Department of Commerce, strongly supports the reform, and has noted as an instance of the present confusion that the Philadelphia Mint uses three different standards of

weight in the purchase of ordinary supplies, in that of metals, and in its laboratory, respectively.

A not unimportant step in furtherance of the adoption of the metric system has recently been taken in the gem-dealers' industry, and although this particular application may appear to many at first sight as being of comparatively slight consequence, its educational effect will be more far-reaching than is generally supposed. This concerns the adoption, in precious-stone commerce, of an international metric carat of 200 milligrams, to take the place of the various and discrepant national carat-weights that have for so long been a source of serious annoyance, inconvenience and loss of time for gem-dealers.

When we reflect that there are some 36,000 jewelers in the United States, and that because of the popularity of their wares they come into constant contact with a large section of our population, we can realize the good work they will necessarily perform in demonstrating to their customers the usefulness of the metric system in this particular case, and thus in arousing public attention to its signal merits.

The chaotic conditions with which gem-dealers had to contend will be appreciated when we consider that there were at least eighteen different national or local carat-weights, ranging from that used at Turin, equivalent to about 3.295 grains (213.5 mg.), down to the Bologna carat of 2.91 grains (188.6 mg.). Hence the heaviest, the Turin carat, was a little more than 13 per cent. heavier than the lightest, the Bologna carat.[1] The impossibility of carrying on a diamond business systematically with such an appalling variation in the weight of the diamond carat, and with no possible means of finding an effective check to determine the accuracy of the weights employed, must be clear to all.

As early as 1893, in a paper read in Chicago before the International Congress of Weights and Measures, held in connection with the World's Columbian Exposition, I suggested dividing the carat into 100 parts, and constituting a standard international carat of 200 milligrams, that is, 5 carats, or 20 pearl grains, to a French gram. This represented a depreciation in weight of only about 2½ per cent. from the carat-weights most in use, and by the universal acceptance of the new standard all the confusing conditions that have so long obtained would be done away with once and for all. Much credit for having definitely initiated this much-needed reform is unquestionably due to Mons. C. E. Guillaume, director of the Bureau Internationale des Poids et Mesures at Sèvres, who energetically and successfully advocated the reform in 1906, before the Commission des Instruments et Travaux, in Paris.

This new standard has now been either exclusively adopted, or officially recognized throughout Europe and America, England having

[1] "The Book of the Pearl," by George F. Kunz and Charles H. Stevenson, p. 323, New York, 1908.

fallen into line by an Order in Council, made on the recommendation of the English Board of Trade, to take effect April 1, 1914. The French law of June 22, 1909, may serve as a model of this legislation, its single paragraph containing the following concise provision:

> In the transactions relating to diamonds, pearls and precious stones, the designation "metric carat" may, in violation of the first article of the law of July 4, 1837, be given to the double decigram.
>
> The use of the word "carat" to designate any other weight is hereby prohibited.

While this law, as well as those promulgated in many other lands, make the use of the metric carat obligatory, in the United States its legalization, coupled with its official adoption and use in the Treasury Department from July 1, 1913,[2] for the customs service, and the support accorded it by the resolutions recommending its use from the same date passed by the National Jewelers' Board of Trade, and the National Jewelers' Association, have given to the metric carat all the sanctions that an ordinance commanding its use could have provided.

Most of us are ready to admit that the use of a universal language would do much to remove the national antipathies leading to the armed conflict of nations, and the universalizing of a simple standard of any kind brings the nations nearer together and helps on a better mutual understanding. When the same signs and symbols express to all the same weights and measurements, this will mean a distinct advance along the road leading to international peace and good-feeling. Whereas all the world can learn readily the words mètre, gram and litre, how many of us know the words for inch, foot, yard, rod, furlong, mile, league in more than two or three languages; yet the term mètre would cover all these and we could all understand what is meant, and accurately.

Our adhesion to the metric standard should be encouraged when we consider that as early as May 20, 1790, Thomas Jefferson, as secretary of state, formulated a decimal system of weights and measures, and embodied the scheme in a report. The adoption of the decimal system in our coinage, already urged by Gouverneur Morris in 1782, probably caused Jefferson to favor its extension to weights and measures as well.[3] Therefore, in adopting the metric system we should only be realizing one of the brilliant and inspirational ideas of the most original thinker among the founders of our republic.

The foregoing testimony plainly shows that the time is ripe for this country of ours to give serious consideration to the question of joining

[2] "The New International Metric Carat of 200 Milligrams," George Frederick Kunz, *Trans. Amer. Inst. Mining Engineers*, New York Meeting, February, 1913 (also the meeting, August, 1913), pp. 1,225–1,245.

[3] S. W. Stratton, director, United States Bureau of Standards, Encyclopædia Americana, art. Metric System.

with the other progressive nations of the world in doing business on a metric basis. Is not this the place to take preliminary action toward bringing about this needed reform? We have here representatives from many lines of commercial endeavor, each of whom believe that metric legislation must eventually obtain in this country. It would be a lasting pity, if before we adjourn this evening, we do not form some sort of an organization whereby the several metric committees represented at this gathering, as well as individuals interested in the metric cause will be held in touch with each other. Such an organization should be dedicated to the promotion of metric education and legislation along rational lines.

Our first step should be to bring the commercial organizations of this country to a realization of the fact that our present system of standards is injurious to our foreign trade and is wasteful of vast amounts of our most precious commodity—time. This accomplished, we should proceed to urge legislation along such lines as will bring the needed reform to those who wish it with the least amount of annoyance to those who for their own reasons oppose it.

I believe it entirely feasible to arrange legislation, either by optional use of the two systems of weights and measures for a certain term of years, or by temporary exemption of certain types of machinery manufacture, so that the change can be made with a minimum amount of loss or trouble. I feel that such work is a patriotic duty of all of us present this morning. I believe that we have right now an unusual opportunity for making the metric system, the American, as well as the International Language of Commerce.

BIOLOGY AND THE NATION'S FOOD

By Dr. W. J. SPILLMAN
U. S. DEPARTMENT OF AGRICULTURE

WE may, without argument, assume that at least a part of the recent rise in prices is due to the wastefulness of war. We know also that the crop year now closing was below normal, not only in this country, but also in others. If the entire difficulty were due to these two causes we might look forward to the future with complacency, for wars come to an end and bad seasons are only occasional. Let us inquire whether there are other, and more permanent, causes.

During the last decade of the last century the average price of farm land in the United States rose 108 per cent. During the same time there was an average increase of 67 per cent. in the price of farm products. Thus far in the present decade both these rates have been exceeded.

This increase in the price of land is due to two principal causes. In the first place, by the early nineties the more desirable portions of the public domain had been settled, and those who a few years earlier would have homesteaded new land were now confronted with the necessity of buying. This greatly increased competition, and prices rose accordingly.

But the very fact that good farm lands were not coming into cultivation as rapidly as formerly lowered the rate of increase in production. This caused higher prices for farm products, and this in turn a further increase in the price of land. It appears therefore that we have arrived at a period, or are rapidly approaching it, when increase in production of food no longer keeps pace with increase in population. Let us now consider a few of our leading food resources to see whether this conclusion is justified.

The average annual production of wheat in this country by ten-year periods for the last three decades has been, in bushels per capita, 7.3, 7.8 and 8.0, respectively. These figures indicate a slight increase in production as compared with increase in population. But these are ten-year averages. The area of our wheat crop for each of the last ten years, ending with 1915, has been, in millions of acres, 47, 45, 48, 47, 46, 50, 46, 50, 54 and 60, respectively. The marked increase last year may be attributed to the stimulating effect of the high prices incident to war. It must also be remembered that by far the greater portion of the land brought into cultivation during recent years lies in the

western wheat-producing area. We can not expect the present increase in the area of new wheat lands to continue much longer. While the production of wheat last year shows that, under the stimulus of high prices, American farmers can still produce a big surplus of this commodity, there is also every reason to believe that such stimulus is necessary. At present we have reached a stage where any great increase in wheat acreage—in fact, an increase proportional to increase in population—can occur only by decreasing the area of other crops. This means that unless we are to have bread still higher in price we must devise means of increasing the yield of wheat per acre.

While wheat is our most important bread crop, corn is a far more important crop when considered in its entire relation to our national economy. It occupies nearly twice the acreage of any other crop, has a total value more than twice as great, and is the principal basis of meat production in this country. The per capita production of corn for the last four census years is 35, 34, 35 and 28 bushels, respectively. The total production for each of the last ten years has been, in hundreds of millions of bushels, 29, 26, 27, 28, 29, 31, 24, 27 and 31. These figures indicate practically no increase for the last decade, during which population increased probably about 20 per cent. Even the great crop of last year was only equal to that of three years earlier. It is evident that we have reached a point where increase in the production of corn is not nearly keeping pace with increase in population. In fact, the statistics indicate that it requires the stimulus of very high prices to bring about even a small increase in the volume of this our most important crop. One reason for this situation is that the West, where most of the lands now being brought into cultivation are found, is not adapted to the production of corn. The acreage of corn is so large that any considerable increase in it can occur only at the expense of other important crops, except as additional land is brought into cultivation in the corn-producing states, and this must, in the nature of the case, be a slow process. We must therefore look very largely to increase in the acre yield for future increases in this highly important crop.

Coming now to that class of food products represented by the fruits and vegetables, we shall find the situation quite different. The entire fruit crop of this country occupies only two and three fourths per cent. of our crop area; the entire crop of garden vegetables occupies another two per cent., of which two thirds is in potatoes. So far as available land is concerned, the area of crops of this character can be increased as occasion requires for a long period in the future. All available statistics indicate that the area of such crops is expanding as rapidly as there is any need for them. The problem of distribution of products of this character is becoming more or less acute, but when there is any actual shortage of any of them the resulting high prices almost in-

variably result in overproduction the next year, or as soon thereafter as a new crop can be matured. It would, however, be far from the truth to state that there are no problems connected with the production of fruits and vegetables. Some of these will be mentioned later.

In this connection it may not be out of place to remark that the present abnormal price of potatoes is due neither to the European war nor to an approaching permanent shortage in this crop. The crop planted last spring was in fact unusually large, and in some localities production was a maximum. But in several large producing centers there was an almost complete failure of the crop because of unfavorable weather. That potato production is keeping pace with increase in population is strongly indicated by the per capita production for the last four census years, which was 3.5, 3.5, 3.7 and 4.7 bushels. The figures for recent years confirm this conclusion. The only present menace to this crop is the possible introduction and spread of fungus diseases, which it is the province of the biologist to prevent. In this connection it may be noted that only recently quarantines were in force against the importation of seed potatoes from infected regions.

There was a time when the American people were probably the equal of any people in the world as consumers of meat. That was when we had an excess of good agricultural land. For the Caucasian race at least the per capita consumption of meat is closely related to the surplus of available farm land. At present we stand third in this respect, being exceeded by Australia and New Zealand, and closely followed by Argentina and Canada. The per capita figures for these five countries are 262, 211, 171, 140 and 137 pounds, respectively. At the present time Australians eat fifty per cent. more meat than we do. As already intimated, the per capita consumption of meat in this country is decreasing. For the year 1900 it was 182, and for 1909 it was 171 pounds, a decrease of 11 pounds in nine years. That this decrease will continue seems highly probable, though not necessarily at this rate.

The important food-producing animals of this country are, in the order of their importance, cattle, swine, poultry and sheep.

From the standpoint of our problem cattle must be considered in two classes, namely, dairy and beef, though there is considerable duplication in these classes. Dairying is, or can be made, a relatively intensive type of farming. For this reason its status can be maintained even when population becomes quite dense. At present the number of dairy cows in this country is increasing approximately in the same ratio as population, and there is reason to believe that this increase may continue for several decades at least. A future supply of butter and cheese seems assured, but there is some difficulty in the matter of supplies of market milk for our growing cities. This is largely due to the greatly increased cost of the methods which now appear to be necessary in the

distribution of this product. Whereas milk was formerly retailed from cans, it must now be bottled. The big problem here seems to be that of reducing the cost of distribution. Improving the quality of the cows as a means of reducing the cost of production is also urgent.

The supply of beef cattle in this country has fallen off very materially in recent years. While at present high prices for animals of this class render it possible for the corn-belt farmer to grow much of the feeder stock formerly obtained from the ranges, there is no reason to believe that we shall ever see beef as plentiful and cheap as it was a few years ago, though the eradication of the cattle tick in the south, now in rapid progress, will open up a large area to beef production.

During the last census period there was an increase of about twelve per cent. in the number of swine in this country, as compared with a twenty per cent. increase in population. There was a decrease of about eight per cent. in per capita production of pork products. While beef cattle represent a relatively extensive form of agriculture, and may therefore be expected to decrease at least relatively as the necessity for more intensive agriculture becomes more urgent, this is not necessarily the case with swine. They can be produced within limits in a very intensive agriculture, especially in connection with the production of butter and cheese. The decrease in per capita production in recent years is due partly to the high price of corn and partly to the prevalence of diseases. Many farmers keep few or no hogs because of the danger of loss from this cause. The eradication of diseases of these animals therefore appears to be a problem of increasing importance.

Poultry farming is even more intensive than dairying. It is more or less prominent in China, where population is so dense as to exclude almost every other type of meat-producing animal. There is, therefore, no economic reason why poultry and eggs should not continue indefinitely to furnish the basis for breakfast and for the Sunday dinner as they have done from time immemorial. In fact, the decreasing supplies of other meats, especially beef and mutton, greatly emphasize the importance of the feathered tribe. The percentage increase in the number of poultry in this country during recent years has been only slightly less than that of population, but there has perhaps been a compensating increase in productiveness. This increase in productiveness is to play an important part in supplying food in the future, and is a biological problem of the first order.

Sheep husbandry as ordinarily conducted represents the least intensive form of live-stock farming. These animals can subsist where no other domesticated animal can live. Hence they occupy the dry regions of the earth, especially of Asia, Australia, Argentina and the western United States. But these regions can no longer supply any considerable proportion of the needs of mankind for the products of these animals.

Partly for this reason and partly because of the increasing scarcity of beef, the price of mutton has risen very materially in recent years, so much so in fact as to raise the question whether sheep may not again become an enterprise on the ordinary farm. These animals are subject to certain serious internal parasites that are of little importance when the animals are kept on the open range and seldom tread over the same ground twice in a season; but when confined on farms, where they must cover the same ground repeatedly each season, the problem of controlling these parasites becomes a difficult one. Here again we have a purely biological problem that is critical in connection with the rehabilitation of a farm enterprise that is assuming greater importance yearly.

To recapitulate. Our principal bread crops already occupy so large an area that there can be no large increase in them except as new lands come into use, a process necessarily slow, and as we increase the acre yield. The increase last year in the acreage of wheat and corn, brought about by abnormal prices, was mainly on land ordinarily devoted to pasture and hay. This is significant in connection with the decreasing supply of beef.

The production of fruits and vegetables can increase practically indefinitely, but even then the saving of acreage by increased yield is an advantage not to be ignored.

There is no economic reason why dairy and poultry farming should not continue to increase in magnitude as the need for their products increases. It is easily seen, however, that on account of the magnitude of these enterprises any considerable increase in production per cow and per hen, which we know need not entail a proportionate increase in feed consumed, may result in an enormous saving, most of which may readily be utilized in the production of beef, mutton and pork. The actual or relative decrease in the number of beef cattle, swine and sheep in recent years thus makes the increased productivity of the dairy cow and the hen a doubly important matter. Here is work of great importance for the biologist, and it is a matter of no small gratification that this work is being pushed forward in a most commendable manner.

In the presentation of this subject it has seemed more important to get a clear statement of what the situation is with reference to our future supplies of food than to confine myself to a list of the biological problems connected with increasing these supplies to meet the needs of an ever-increasing population. I have tried to present the situation in such a way as to make clear the relation of the more important of these problems to our necessities. In the time available here it would be impossible even to mention the notable achievements of the last quarter century and the important problems still awaiting solution. I will therefore confine my few remaining remarks to very general considerations.

It is clear that increasing the acre yield of crops is one of our very big problems. It assumes four phases, as follows: (1) Increasing the fertility of the soil, (2) improving cultural practise, (3) protection against diseases and pests, (4) improving the yielding power of the plant.

Most of the questions here involved lie wholly within the field of biology. Some of them involve so many sciences that their solution lags for want of closer cooperation between scientists whose interests are diverse.

Some of the more important phases of the problem of increasing the production of live stock products are: (1) A better understanding of animal nutrition; (2) the eradication or prevention of disease; (3) the suppression of insect pests, animal parasites, and the depredations of dogs and wild animals; (4) the improving of quality and productiveness by breeding and selection.

Great progress has been made in all these directions, but much remains yet to be done. It is a far cry from the 3,100 pounds of milk of the average American cow to the 30,000 pounds of Tillie Alcartra; from the five dozen eggs of the average American hen to the 26 dozen of Lady Eglantine. We can not hope to raise the average to these high figures, but the general application of principles already known and the successful completion of studies now in progress would go far in this direction.

ADVENTURES OF A WATERMOL

A ROMANCE OF THE AIR, THE EARTH AND THE SEA. III

BY PROFESSOR H. L. FAIRCHILD
UNIVERSITY OF ROCHESTER

SYNOPSIS OF THE PUBLISHED CHAPTERS: In the January and February numbers of the MONTHLY the molecule of water has related the story of its volcanic birth in very ancient geologic time and a few of its romantic experiences in wandering over this old earth; adventures in cloud, river, ocean, glacier and iceberg; in ancient plants and animals, and in the outer limits of the atmosphere. It describes its geologic work in pulling down the continents and dragging them to the sea. The story is completed in this issue.

EXPERIENCES IN MESOZOIC TIME

WHEN I escaped from the calms of the equatorial belt I was again in the northern hemisphere. Then it was middle Reptilian or Jurassic time. The huge and wonderful reptiles then ruled the world. Some birds and mammals were living, but they were small in comparison with the big reptiles of both land and sea. I had my experiences with the creatures.

Once when I was in the leaf of a palm one of the enormous reptiles that stalked about on their hind legs, called Dinosaurs, ate my leaf as part of his dinner. When the leaf was digested and I was liberated in the digestive tract I was indignant. Then I was absorbed into the blood circulation, and finally built into the flesh of the huge beast. I think I was in his arm or front leg. When this fellow, the Brontosaurus, which was fifty or sixty feet long, was killed and partly eaten

FIG. 23. WATERMOLS WINTERING IN COLORADO.

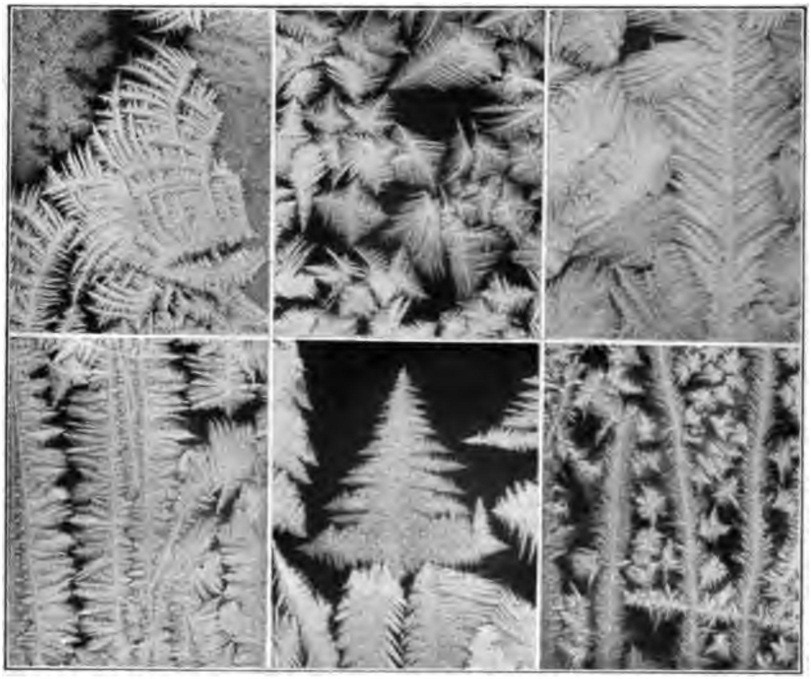
FIG. 24. WATERMOLS TAKING A LONG VACATION.

by a carnivorous Dinosaur I was transferred to the body of the latter. This fellow stalked about on the land on his hind legs, and was the lordly ruler of his time. His favorite range was the region that is now New York and Pennsylvania.

If I were romancing I might tell how I had been in the body of one of the huge dragon-flies of the Jurassic time which was devoured by the flying reptile, the Pterodactylus; or that I had been in the brain or eye of the most ancient bird, the Archeopteryx. But I must hold to the truth. I only saw these remarkable creatures of the olden time.

After various adventures I found myself during Cretaceous time, or later Reptilian period, in the Atlantic ocean. Here I helped in my small way to make the chalk. I was in the protoplasm or soft simple flesh of a microscopic animalcule which had a lime shell. This little Protozoan belongs in the class Foraminifera. Millions on millions of these microscopic beings were floating in the ocean, and when they died and their watery flesh dissolved the tiny shells slowly settled down through the water and, falling on the bottom, made the white, soft deposit known as chalk. The shell which was built by my protozoan fell near Belfast, in Ireland.

Later I was in the substance of the giant Foraminifera which produced the Nummulitic limestone of the region about the Mediter-



W. A. Bently, photo.

FIG. 25. SAMPLES OF WATERMOL ART WORK.

ranean. The shell of my Nummulite is now in a block of limestone which is built into the Great Pyramid. I think that I may rightly claim to have helped build the Pyramids, as truly as if I had been in the blood or brain or muscle of one of Pharaoh's slaves.

IN THE BLOOD OF MAMMALS

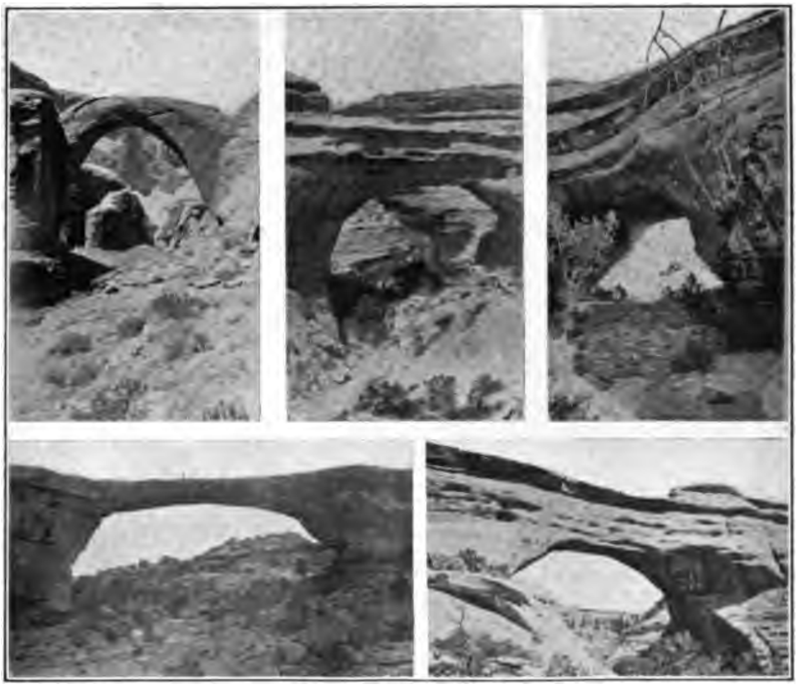
We might as well pass over the events during two or three million years, and come down to the midst of the Age of Mammals, or Tertiary time.

With the evolution of life on the globe new and interesting adventures were possible. When in the development of animal life high body temperatures and hot blood were produced I had experiences very different from those which I had in the body of the seajelly, or even in the real but cold blood of the ancient big reptiles.

One day I was in a trickle of water in an oasis of Asia, and some brute of the camel family happened along and drank up all the water. For days I was carried in his water-tank stomach. At last this water was absorbed and I was carried into the hot blood and finally built into one of the tiny red corpuscles. In this corpuscle I traveled about the camel's body thousands of times. The blood current in which I

floated was truly a river of life. The red corpuscles and the thin, white fluid in which they floated, was swept rapidly through a stiff tube, the pulmonary artery, which quickly divided into small branches and finally into minute microscopic tubes, the capillaries, which were spread over the surface of the lung cells. Here, in the capillaries, the red corpuscles gave up some of the carbon-dioxide that they carried in combination with iron, and took on instead some oxygen, which changed the color of the corpuscle to a brighter red. This exchange of gases was through two membranes, the wall of the blood tube and that of the lung cell. Then with our load of oxygen we passed on through the capillaries into larger and larger tubes, the pulmonary veins. These poured us all into a sort of bag, called the left auricle. From this cavity we were sucked into a second, connecting chamber through a curious door consisting of three parts or valves. Then the thick, muscular walls of the second chamber, the left ventricle, suddenly collapsed or contracted and we were forced in a swift current through another large and stiff tube, the aorta, into the body substance of the animal.

The large tube divided and subdivided into thousands of branches, and these into minute tubules, the capillaries. Some of the larger tubes, systemic arteries, carried blood to certain muscles, some carried



N. M. Judd, photo.

FIG. 26. SAMPLES OF WATERMOL BRIDGE WORK.

Fig. 27. Joint Work of Watermols and Windmols.

to the stomach, some to the brain, and some even to the muscle walls of the pump or heart itself. Every minute part of the animal's body was supplied with tubes and blood, except the hair and hoofs, which are dead matter.

I helped to carry the oxygen to all parts of the camel's body, sometimes to his brain, or his muscles, or his eye, or bones. The fluid part of the blood, in which the corpuscles floated, also carried the nourishment to all parts of the body, and this came from the food through the stomach and intestines.

The red corpuscles were like little boats in the river of the blood, carrying only the life-giving oxygen to the substances of the body. The oxygen burned up the old, or worn-out cells, so producing carbon-dioxide. This burning of the waste matter caused the heat of the body. Then the corpuscles took on a cargo of carbon-dioxide in exchange for the oxygen.

When we were through the capillary tubes, in whatever part of the body we happened to be, and had finished our work of changing cargo, we were gathered into larger and larger tubes, called veins, and finally into a big, soft tube, the vena cava, which poured us into a bag or chamber, the right auricle. From this we were drawn through another curious door into another chamber, the right ventricle, which suddenly contracted and sent us swiftly through the tube, the pulmonary artery, where I began this account of the blood circulation.

We watermols composed nearly all the substance of the blood fluid, the plasma, and of the corpuscles. Sometimes I was in one and sometimes in the other. It was lively work, getting nourishment from the food canal and oxygen from the lungs and carrying them to every cell of the whole body, and then taking away the waste material. We made a round trip, as described, in about one half of a minute, most of that short time being spent in the two sets of capillaries while changing cargoes. I was a part of the navigation system in the camel, and in the years that I was in that business I must have traveled a great many thousand miles. But I did not arrive anywhere.

It seemed that I might never escape. But one day, or night, for night and day were all the same, and we had no half-day or week-end holidays, we were hustled along unusually fast, for the pumping apparatus, the heart, was working tremendously because the camel was running. Then, of a sudden, everything stopped. The old camel was dead. He had been chased and killed by a tiger.

The tiger drank some of the camel's blood, and I was in the tiger. To make a long story shorter, I was carried into the tiger's blood, and for a time, a year or two, I served as a galley slave in the internal navigation system of the beast. It was similar to the work in the camel, only more rapid and with higher temperature.

Courtesy of Eastman Kodak Co.
FIG. 28. WATERMOLS TAKING A PLUNGE.

My escape from the tiger was in an unexpected and curious manner. One day, somewhere in southern Asia, my host, the tiger, had a fight to the death with an elephant. The elephant crushed him by kneeling on him, and some of his blood ran out on the ground. And so when the blood dried I escaped into the air.

AS A WORLD-EXPLORER

This story can tell only a part of my history of adventure in wandering about the earth. Many times that I need not describe have I been in the upper air; in cloud and terrible hurricane; and in the arching rainbow. Many times I have fallen into salt and fresh waters. I have helped to swell the Mississippi river and Gulf of Mexico; the Volga and Caspian sea; the Hwangho and Yellow sea; the Mackenzie river and the Arctic ocean.

Once I fell in Lake Victoria Nyanza and floated down the Nile and past the Pyramids, whose material I had helped to form, so many millions of years before. In this trip I was stranded on the Nile delta, and after a variety of happenings I found myself in the milk of a

cocoanut. I had once been in the warm milk of a kangaroo, but this was different. A monkey cracked this nut and drank its milk, and there I was, in the monkey. But being in the stomach and blood and muscle of monkey is just about the same as in a man or a tiger.

One of the queerest events was when I had drifted to Australia and somehow had found myself in the egg of the duckbill, or platypus. I knew that it must be a mammal, because it had hair and warm blood. But when it laid a real egg with me in it, why, that really was something new. I just laughed and laughed until it spoiled the egg.

While I was in Australia I climbed in the sap of an Eucalyptus tree to the topmost branch, over three hundred feet high. This was higher than when I was in a California Big-Tree. But it was a glorious trip, in the High Sierras of California. When I was transpired from the leaf of the Big-Tree, the Sequoia Washingtonia, I was caught in a snowflake and fell on Mt. Shasta. When the snow melted in the springtime I went out into the Pacific ocean.

In this trip to the Pacific I had another queer adventure. In some way or other I found myself in a huge animal in the sea. It ought to have been some sort of fish, being so far out to sea. But it had warm blood, so I knew it must be a mammal. In my long life and varied experience I have learned a few facts. The beast was a whale. And one

FIG. 29. A RECKLESS JUMP.

FIG. 30. AN UNFINISHED JOB.

day I was in the moist air of his lungs and he came to the surface of the sea and spouted the air into the atmosphere. That was the oddest way that I had ever found of getting back into the atmosphere. The nearest to it was when, in New Zealand, I got into the hot water of a geyser and was spouted by the exploding water of the geyser into the atmosphere. Speaking of spouts, I was once in a waterspout on the Atlantic.

In contrast with these events I may mention a few more dainty and quaint experiences. I have often been in the dewdrop on the grass and in the frost on the window-pane. I have been in the luscious fruits of both temperate and tropic climes; and in the fragrant nectar of many flowers.

Once in the honey sac of a clover blossom I was found by a bee, who took me in the nectar and packed me away in a wax cell of its honey-comb. This was a sweet time; even sweeter than when, in recent days, I was in the sap of sugar-cane and went through all the processes of the sugar mill. Finally one of the workers in the hive fed me to the queen bee, and I was a part of her royal ladyship. Then I passed out in one of her many eggs which became a male bee, or drone. He was stung to death by the workers for his lazy uselessness, and on his death I was liberated into the air.

Experiences with Man

The appearance on the earth of the human animal gave opportunity for new experiences. Many of the tragedies in my later life, and some of the comedies, have been due to the singular circumstances produced by the activities of man. He seems to have brought, especially through his use of fire and control of electricity, new conditions or relations into the world.

I recall how in recent time I was once in the sap of a maguey plant, in Mexico, the agave, called in the north the century plant. A Mexican peon came along and cut out the large bud that would have pushed up as the fruit stalk. The sweet sap that collected in the cavity was sucked out, by the Mexican, with myself in it, and put in a pigskin bag and sent into the City of Mexico. This sap when fermented made the Mexican national drink, called pulque. I was in the pulque that was drunk by a Mexican, and—well! never mind the rest of the story. There are multitudes of peculiar drinks, better or worse, and mostly bad, and all composed chiefly of us watermols. I have been in several of them, but pulque was the "limit."

In China I had another poor time. While in a stream I was scooped up into a big cask and carried for months in the hold of a pirate junk. Then the Chinamen put me in a dirty kettle and boiled us with some tea leaves, and then drank us while hot.

Speaking of hot things reminds me of the hottest time that I ever had. It was the occasion of the great fire in Chicago. It seems to have been my luck, or misfortune, to be around so many times when

Fig. 31. Watermols in Repose.

Eastman Kodak Co.

FIG. 32. WHERE WATERMOLS NEVER REST.

something unusual was happening. Just then I was in the edge of Lake Michigan, and a fire engine sucked me out of the lake, pushed me through a long pipe, and then squirted me into the fire. That was the hottest ever; even hotter than in the New Zealand geyser. But I helped as much as any of the water to put out the fire.

Once I was in the sulphur water of a famous health resort, and was taken in by a pretty girl. But that was not specially different from being in a monkey or a whale.

GOOD-BYE

I am the true symbol of Life. All the organic substance of the world, the "living things," are composed of such as I. Combined with some nitrogen we form protoplasm, the basic substance of all life. Without us watermols there would be no plants or animals, and no food or drink. Of course there could be no lake, or river, or ocean; no beauty cloud of rosy sunrise or crimson sunset.

We do the work of the world. On us floats all the commerce of the water-world. We are the steam of your engines, and we are the masses of falling water which supply the power for your machinery or for changing mass energy to electricity.

We are also the great agent of destruction. All decay is by means of water. We rend the rocks by our expansion under cold. By wave and stream and glacier we slowly drag everything, even the mountains, into the sea. Sometime we may cover all the surface of this earth.

Like all living things I, individually, am not immortal. But my units, or atoms, are. My substance is eternal. There are ways in which I might be destroyed, particularly by human devices. Very intense heat would drive apart my three atoms. I feared this when I was caught in the Chicago fire. In some chemist's laboratory I might be destroyed by some chemic reaction. And a lightning bolt might separate my atoms.

But I have existed so many millions on millions of years that I expect to last awhile. I am still young and seeking diversion and adventure. I can not predict at all where I may be during the coming one hundred million years. Possibly I may conclude to leap away from the earth into outer space and seek some other less known field for far adventure.

But you may look for me yet awhile. Think of me in the high frost crystal of the cirrus cloud, or as down in the abyssal depth of the deepest and coldest ocean; or in the falling snowflake, or the rising mist of the morning; or in the cloud-banner on the tropic mountain top or in the cold fog of an arctic valley; in the peaceful rainbow or in the terrible tornado; perhaps in the sparkling draught of your happy festivals, or in the idle tears of pretty girlhood.

Now, I must be going. Rest is impossible, even for a watermol. There are more adventures to come, and I seek them. Good-bye. We may meet again.

FIG. 33. GOOD NIGHT.

THE EXPERIMENTAL METHOD AND SOCIOLOGY. II

By PROFESSOR F. STUART CHAPIN
SMITH COLLEGE

SOCIAL LEGISLATION IS SOCIAL EXPERIMENTATION

ONE of the most interesting sociological experiments of modern times, both because of its method and scope, is the vast social insurance scheme of the German Empire. It is a case of deliberate social experimentation. It is now quite generally recognized that under the contemporary organization of industry which has resulted from the industrial revolution, the great masses of working people of industrial nations receive inadequate wages as tested by the necessity of meeting the inescapable hazards of accident, sickness, death and old age. A knowledge of this fact as well as a variety of separate contributory influences, foremost among which was several years' experience with sick benefits among labor organizations, led the German government to formulate a plan for three branches of insurance—against sickness, against industrial accident, and against old age and invalidity. These respective bills of the year 1881 became laws in 1883, in 1884 and in 1889. Under them millions of German working people have been insured and have received protection which they could not have secured by individual assumption of the risks. Benefits granted under the law are considered payments of legal obligation and not a public charity. The success of this vast experiment seems to be shown by its continuance as a settled policy during a period of great industrial and commercial expansion, and by its recent imitation on the part of Germany's great competitor, England. It is claimed by Germans that no small part of their country's remarkable national unity in The Great War is due to the strengthening effects of thirty years of social insurance among the masses of the people.

But the German experiment was superimposed from above and does not illustrate democratic experimentation. For examples of sociological experimentation more directly initiated and sanctioned by the people, we must turn to England and America. Considering the United States first, we find that social legislation on the Pacific coast constitutes a remarkable example of social experimentation.[28] The principles involved in the experimental direct legislation forms of initi-

[28] Ogburn, W. F., "Social Legislation on the Pacific Coast," *Popular Science Monthly*, Vol. LXXXV., No. 20, March, 1915, pp. 274–289.

ative, referendum and recall, the direct election of senators, the minimum wage and other specific labor class reforms, are too well known to require elaboration here. It will suffice to outline the scope of such legislation by quoting Professor Ogburn, who says:

> The new states have not hesitated to experiment. It is well to see these experiments in summary. Oregon was the first state to adopt the recall, the direct election of senators, the presidential preference primary, to pass an extensive ten-hour law for women and to put into effect the minimum wage law for women. California was the first state in scientific budget making. Washington was first to abolish private employment bureaus and is first in the efficiency of public schools. Oregon was third to provide for the initiative and the referendum and was first to develop them. Oregon was second to adopt the direct primary and California was second to put into effect a law requiring the reporting of industrial diseases. There were only two states to precede the Pacific coast states in creating mother's pensions. In adopting other social legislation, while not the first, second or third states, Washington, Oregon and California were in a small leading group to legislate on home rule for cities, child labor, hours of labor on public works, factory sanitation and inspection, employers' liability, eugenics, prohibition, prison reform, public utilities, municipal ownership, the social evil and woman suffrage. The success of these experiments may be interpreted by observing the extent to which other states are following their example. . . .[29]

Sociological experiments which aim at better relations of labor and capital, more equable distribution of wealth or more efficient methods of production are seen in the Grange and Farmer's Alliance of America, the California Fruit Grower's Association, the profit-sharing schemes of the Pillsbury Mills of Minneapolis, the Proctor and Gamble Company of Dayton, Ohio, the housing and welfare work of the Lever Brothers at Port Sunlight, near Liverpool, England, and the Cadbury Brothers of Birmingham, England. The list of social experiments of a semi-public nature is well-nigh endless.

But returning to state-initiated experiments, the English experience with social insurance is as yet too brief to permit any satisfactory conclusions. Yet in the field of factory legislation some interesting effects may be observed. It has been pointed out by Professor Karl Pearson[30] that coincident with the era of factory legislation there has been a marked decline in the birth rate of women 15 to 55 years of age in the manufacturing towns. During the period 1864 to 1891, a series of factory acts were passed which applied to bleaching and dyeing works, copper, steel and iron, textile mills and mine work, which restricted the labor of children by raising the age limit and cutting down the hours of work. Educational standards were raised and school attendance enforced by the education acts of this period. As a result, the child ceased to be an economic asset to its parents till the age of 13 or 14 years. Prior to the factory acts a large family was an advantage to a

29 *Ibid.*, p. 289.

30 "The Problem of Practical Eugenics."

workman, for the children were put to work at an early age and soon contributed to the family income. When the working-age limit was raised and the hours of labor restricted to remedy the inhumane conditions of child labor and to provide education for the younger generation, the immediate economic value of the child was diminished. Pearson claims that the economic value of the child of the labor classes will in the long run govern its production. Hence the decline in the birth-rate of the English laboring classes. But he also claims that the decrease in quantity has not been compensated by better quality, as is ordinarily held, for he maintains that the first-born members of a family are most likely to be abnormal, *i. e.,* neurotic, insane, tuberculous and albinotic, than those subsequently born.[31] Whether we accept the last corollary or not,[32] the diminished birth-rate is an undoubted fact and an unexpected sequel to the factory acts, which shows that all conditions in the experiment were not known at its beginning.

The Difficulties of Experimentation in Sociology

The foregoing account supplements the general impression that the results of much experimental social legislation are as yet indefinite and inconclusive. The difficulty seems to be that every problem is more complex than was first suspected, and in the present state of our knowledge some unforeseen factor usually appears to upset our plans and invalidate our conclusions. In other words, few of the conditions of the experiment are known and consequently it is not possible to attain control. Is this fact fatal for the experimental method in sociology?

We have seen that the method of experiment was to vary one condition at a time and keep others constant or under control. But how know what the others are? Only by the method of trial and error are the other conditions discovered. In the early development of the now exact physical sciences, the method of trial and error was the only method which led to discovery. By this rough method the main conditions have been discovered and the way blocked out. At the present time, with many conditions known, there is a considerable field of experimentation in physical science that is mere repetition by control of conditions previously discovered. The physicist may now set up an experiment with great precision and attain definite results. It may, therefore, be legitimate to distinguish two stages in the experimental method—a pioneer stage of empirical experimentation by the rough trial and error method, and a precise stage when many conditions are known and so easily controlled.

If this distinction is approximately true, then the record of social

31 *Ibid.*, pp. 19–21.

32 Pearson, K., "On the Handicapping of the First-Born," 1914, and criticism of Pearson's memoir by L. I. Dublin and H. Langman in No. 112 of the *Quart. Pub. of Amer. Statistical Assoc.*, 1916.

experimentation would seem to show that the sociologist is still in the first stage of the experimental method. Will he ever attain the second or precise stage of experimentation?

Let us first analyze the meaning of the statement that sociological experimentation is in the pioneer stage of trial and error experimentation.

The method of trial and error is a law of very general application in the realm of living things. Regarded from a philosophical point of view it might be said that natural selection is simply the operation of the method of trial and error in the physical world. Organic life is continuously putting out tentatives in the form of spontaneous variations. Some of these variations persist, others perish. Natural selection is the term used to describe the process by which some variations are selected and others rejected. The agents of natural selection are: limitation of food and water supply, draught, climatic change, extremes of heat and cold, storms, wild animals, genetic increase, etc. These agents act upon the structures of organic individuals, producing immediate effects in the extermination of most individuals with inadapted structures, and ultimate results in the survival and perpetuation of individuals with adapted structures. It appears that organic individuals are significant and important from the evolutionary point of view, only as they bear and transmit adapted structures. By this trial and error method, nature finally evolves her adapted type of inhabiting species.

In society there is an analogous process in the principle of social selection. Human beings are continuously putting out tentatives in the form of individual and collective reactions to stimuli. Repetition of these reactions produces habit in the individual and custom in the group. Individual variations from the conduct approved by the group constitute the raw material of social selection. Innovators and radicals are subjected to group pressure to change their ways and to conform. Thus the agents of social selection—group ostracism, persecution and punishment—act upon individuals with anti-social ways, and produce immediate effects in the extermination of anti-social individuals or in the repression of anti-social ways. The ultimate results are seen in the survival and perpetuation of adapted ways and customs. Thus human individuals attain significance from the social evolutionary point of view, only as they bear and transmit adapted habits and customs.

But unlike natural selection, social selection attains its results, the survival and perpetuation of adaptations, by two processes. It is necessary to distinguish these two levels in social selection in order to apprehend the true significance of the trial and error method in society. Natural selection secures the essential adaptation by extermination of

inadapted forms. Social selection accomplishes adaptation (in habit and custom) in primitive stages of social development, and to a lessening degree in higher stages, by the extermination of anti-social individuals; but adaptation is also secured by social control which falls short of life destruction and simply represses and constrains.

It is this second aspect of social selection which marks it off from natural selection as a more discriminating process. The survival of adapted structures can not be attained by any means other than the extermination of individuals with inadapted structures, since the structure can not be separated from the individual and because the laws of physical heredity are rigid. If the non-transmissibility of acquired characteristics were not so generally substantiated as a principle of evolution, we might look for the perpetuation of adaptations without physical extermination. On the other hand, the significant thing for society is habit and custom, traits which can be separated from the individual and modified in the individual. Hence adaptation in habit and custom may be secured by constraint. Ostracism, persecution and punishment, are some of the forms of social pressure which lead individuals with anti-social habits and customs to rearrange their mode of conduct and conform to the approved standards. Much of modern educational practice is based upon this fundamental principle.

If it is permissible, as it seems to the present writer, to roughly distinguish two methods in social selection, it would be well to differentiate between them in terminology. The writer, therefore, uses the term social selection to designate the process by which society secures adaptation in individual habit and conduct through the means of excluding or exterminating anti-social individuals, and the term societal selection to designate the process by which society secures the preservation of adapted habits and customs by means of social constraint.

This distinction is in no sense identical with that made by Professor Albert G. Keller[33] between automatic and rational selection as forms of the general social process which he calls societal selection. The present writer considers that Keller's distinction is not more fundamental than this one. Moreover, the distinction just made enables the sociologist to avoid the looser sort of analogical reasoning and to see at once into the heart of the selective process of society. For example, social selection, as defined above, may be both automatic and rational, the group may react suddenly and under stress of emotion cast out or kill the offender, as in the case of a lynching; or the group may exclude or kill the offender after mature deliberation, as in criminal procedure. Similarly, societal selection, as defined above, may be both automatic and rational; the group may react quite thoughtlessly and require conformity to the established customs, as in the ostracism of Gorki; or the group may consider the situation carefully and decide

33 "Social Evolution," 1915, especially Chapters 3, 4 and 5.

to abolish the offending custom or way, as when a legislature repeals a statute and enacts a new law to take its place with due provision for enforcement and penalties. [The passage of a law which punishes felony with imprisonment or death is an example of rational societal selection, whereas the operation of the law by which the felon is separated from society and imprisoned is an example of rational social selection.]

It should now be clear that collective experimentation of the sort to be compared with the experimental method of the physical scientist is simply rational societal selection.[34] But rational selection as illustrated by the procedure of legislative enactment, the initiative, the referendum, and by the decisions of semi-public or class legislative bodies, is simply the trial and error method carried on by collective action.

The truth of this statement will be recognized when one considers the vast amount of legislation which fails to correct the evils it aims at, and when one considers the numerous group and class experiments that have been inconclusive or even disastrous failures. We are now beginning to understand that legislation and all social experimentation should be guided by a more accurate knowledge of facts. Lester F. Ward said:

> When the people become so intelligent that they know how to choose as their representatives, persons of decided ability, who know something of human nature, who recognize that there are social forces, and that their duty is to devise ways and means for scientifically controlling those forces on exactly the same principles that an experimenter or an inventor controls the forces of physical nature, then we may look for scientific legislation.[35]

Again,

> It must not be supposed that such legislation can be conducted to any considerable extent in the open sessions of legislative bodies. These will doubtless need to be maintained, and every new law should be finally adopted by a vote of such bodies, but more and more this will become merely a formal way of putting the final sanction of society on decisions that have been carefully worked out in what may be called the sociological laboratory. Legislation will consist in a series of exhaustive experiments on the part of true scientific sociologists and sociological inventors working on the problems of social physics from the practical point of view. It will undertake to solve not only questions of general interest to the state—the maintenance of revenues without compulsion and without friction and a smooth and peaceful conduct of all the operations of a nation—but questions of social improvement, and amelioration of the condition of all the people, the removal of whatever privation may still remain, and the adoption of means to the positive increase of the social welfare, in short the organization of human happiness.[36]

Social Experimentation and the Statistical Method

We are still in the trial and error stage of social experimentation. It will be some time before all the conditions of any social problem are

[34] *Ibid.*, Chs. 4, 5.
[35] "Applied Sociology," 1906, p. 338.
[36] *Ibid.*, also "Dynamic Sociology," Vol. II., p. 156.

known and probably many years before precise experimentation is possible. But assuming that the sociologist will eventually attain a state of more complete knowledge of social conditions such that the factors entering into any social problem are known, may he not then pass into the precise stage of social experimentation?

The difficulty which prevents precise methods in sociological experimentation is inherent in its data. Social units are complex as compared with the relatively simple units of other sciences. In physical science the units operated upon are homogeneous, standardized; whether in China or America, given the controlled conditions, the experiment will work, it may be repeated. But in sociology the units are not homogeneous or standardized; every unit is unique, individual, different; moreover, there is the constant bias of race, government, standard of living and political ideals. An experiment in China proves little or nothing for America. Welfare experiments, housing reforms, model villages, unemployment insurance, though successful in Germany and England, prove nothing final and conclusive for Americans. Every one of these schemes must be rearranged and adapted to American conditions before it will work—and then the result may be something new, quite unlike the European model. Moreover, while the sociologist is experimenting with human units the factors change, the problem assumes a new aspect, as when legislation to correct an abuse comes after some unforeseen economic factor has already eliminated the evil (American tariff laws and European wars and disturbances). Thus do fundamental differences in race, government, political ideals, and standard of living constitute the uncontrolled conditions which invalidate conclusions that may be drawn from much social experimentation.

It is for the sociologists of the future to attain that stage at which there is complete knowledge of conditions entering into many social problems. Since the contemporary sociologist is denied this advantageous knowledge and is also hampered by the fundamental variability of his data, it would seem that precise results from the experimental method in society are impossible. Is there any means which may be used to supplement the deficiencies and correct some of the faults of the trial and error method applied to the solution of social problems?

Social scientists are beginning to recognize that an efficient tool lies at hand in the statistical method. Two illustrations will serve to show how the statistical method applied to the data of sociology helps to obviate those hindrances to the use of the experimental method which are due to imperfect control and heterogeneity of data.[36a]

In the first place, the statistical method helps the sociologist to discover the separate effects or relations of different factors in a given

[36a] The statistical method may be defined as the group of principles which governs the collection, classification, tabulation and interpretation of numerical facts.

social problem. The marriage-rate and trade per head of population are two sociological variables usually said to be closely related in such a fashion that the marriage-rate fluctuates according to the general prosperity of the country, as shown by the course of trade. But a plot of the marriage-rate over a series of years indicates that there are at least three types of fluctuations superimposed. There is the general tendency of decline in the marriage-rate, the fluctuations caused by alternate periods of general business prosperity or depression, and the seasonal fluctuations due to custom. There is also a complex oscillation in the course of trade: the prosperity-depression fluctuations, and a gradual rise in the trade curve. Mr. R. H. Hooker[87] has computed the coefficient of correlation[88] of the series of marriage-rates with the series of values per head of exports of British and Irish produce for the period 1861–1895, and found $r = 0.18$, with a probable error of 0.09—a very low coefficient, indicating no connection between the two. The difficulty was that the difference in the general movements of the two curves had completely overshadowed the minor oscillations. In order to eliminate the disturbing influence of these diverse general movements and measure the relation of the fluctuations of the marriage-rate with the prosperity-depression cycle of trade, the "moving average" or "trend" was computed and the deviations from the trend used in working out a second correlation coefficient. Thus computed, the correlation was 0.80, probable error 0.04, a high coefficient, showing marked connection between the two series. But since fluctuations in the marriage-rate follow upon oscillations in trade, it is necessary to make allowance for this lag. Using a lag of half a year, *i. e.*, correlating the marriage-rate with the exports of half a year earlier, a maximum coefficient of 0.86 was found. Here, then, is a case involving complex conditions which are beyond the control of the social scientist, yet by means of statistical devices it has been possible to measure the strength of one relation at a time and to form a definite idea of the importance of this relation.

In the second place, the statistical method helps the sociologist to overcome some of the hindrances to precise sociological results, caused by individuality of the units and the consequent heterogeneity of aggregates. The known diversity of personal characteristics seems to thwart any formulation of valid generalization no matter how careful the initial observations. Since every human individual is in a sense a unique case, different from all other human individuals, generalizations must be based upon a vast number of observations if they are to be valid. But

[87] "Correlation of the Marriage-Rate with Trade," *Jour. Royal Statistical Society*, Vol. LXIV., 1901, pp. 485–492.

[88] A measure of the closeness of relation of two associated variables, computed by means of Karl Pearson's coefficient $r = \Sigma(xy)/n\sigma_x\sigma_y$, where x are deviations from the average of one series, y are deviations from the average of the related series, σ_x and σ_y are measures of the dispersion of each series in terms of their respective averages, and n is the number of observations.

in most cases the number of observations which the sociologist can make is strictly limited. Consequently he must rely upon a more or less restricted series of observations to represent the totality of his phenomena. Right here the statistical method furnished valuable aid in its theory and method of sampling.[39] By selecting at random a sample numerically large in relation to the variation among items in the wider universe, a representative group is obtained. The obstacle presented by the diversity of individual characteristics within the sample group may be largely overcome by selecting the form of the average best adapted to the particular data under consideration. For example, when extreme observations are regarded as important, the mean or arithmetic average is usually selected because it gives due weight to extremes; when extreme observations are not important or when the data are not susceptible of measurement in units, the observations may be ranged in order of their size and the mid-most observation, or median, is used as the average; and when there is a distinct central tendency or grouping, the most frequently occurring observation, or mode is used as the average. Furthermore, since in general, the deviations of particular observations from the average follow some ascertainable law, it is possible to attain quite a precise definition of the group and thus overcome many of the difficulties that arise because of the individuality of items and their aggregate heterogeneity.[40] Generalizations arrived at by this process avoid many of the qualifications ordinarily introduced by the fact of excessive variability in sociological observations. In this way the sociologist may partially overcome the second great obstacle to precise methods in his field. It may, therefore, be said that the statistical method bears to scientific method in sociology much the same relation that the experimental method bears to precise methods in physical science.

Summary

To recapitulate: The experimental method has brought notable achievements in physical science. This method consists in controlling all conditions associated with a given effect save one condition, and varying that one. The experimental method has been used in such diverse fields as physics, botany and psychology—can it be used in sociology? Sociologists have already observed the effects of natural experiments—the effect of isolation on the Eskimo, the operation of Malthus's law and natural selection among the Chinese—but have sociologists ever actively interfered with the determining conditions of a social problem to the extent of attaining control of the conditions?

[39] Yule, G. U., "Introduction to the Theory of Statistics," chapters on sampling, and Chapin, F. S., "Elements of Scientific Method in Sociology," *Amer. Jour. Sociology*, Vol. XX., No. 3, Nov., 1914, pp. 371–391.

[40] See Zizek, F., "Statistical Averages," also writings of Edgeworth and Pearson in the *Journal of the Royal Statistical Society* and the *Philosophical Transactions* of the Royal Society.

The social reformer is constantly hindered by moral and superstitious objections to practise of his plans. Even experimentation upon live animals is not sanctioned by all people, in spite of results that have promoted human welfare. Where should the line be drawn between experiments upon live animals and human beings? The voluntary renunciation of personal rights and the assumption by the state of the power to override personal rights are the only justifications for experimentation upon human beings. Society is the only official sociological experimenter. The utopian communities of New Harmony, Brook Farm and the North American Phalanx are examples of community experimentation in simplest terms. But the results of these experiments were inconclusive because the experiment was performed in the social medium. They failed to secure the essential condition of isolation. A good example of sociological experimentation sanctioned by the state is seen in the state socialism of Germany and England. Unexpected results of some of these experiments show that all conditions of the problem were not known. Is inability to control all the conditions in a social problem fatal for the experimental method in sociology? In physical science the conditions of a problem were first discovered by the method of trial and error. When the conditions were known, more precise methods of experiment were possible. Thus the experimental method passes through two stages: a pioneer stage of trial and error, and a stage of more precise experimentation. Sociological experimentation is clearly in pioneer stage of feeling its way. Collective activity is carried on by the trial and error method. There is a social selection of adapted ways analogous to the natural selection of adapted structures. But the selection of adapted ways is by two processes: social selection, involving individual exclusion or extermination; and societal selection, involving constraint and social control. Both social and societal selection are forms of collective experimentation by the trial and error method. Legislative action is societal selection in the trial and error stage of the experimental method, since the results of so much social legislation are inconclusive. But when all the conditions of social problems have been discovered by the trial and error method, may not the sociologist then pass on to the precise stage of the experimental method? The data of sociology are so complex and observations show such great variation, that precise methods seem impossible. Is there, then, no way to overcome hindrances to precise methods of experimentation in sociology which are due to limited control and complexity of data? The statistical method helps to analyze out conditions of cause and effect, and assists in overcoming the difficulties presented by complexity of data. In conclusion, the statistical method bears to scientific method in sociology much the same relation that the experimental method bears to precise methods in physical science.

FAMILIES OF AMERICAN MEN OF SCIENCE

By J. McKEEN CATTELL

II. Marriages and Number of Children

THERE are thousands of volumes containing vital statistics, but exact studies of definite groups of individuals have scarcely been made. It is often assumed that we must have vast numbers of cases, such as are obtained by a national census, in order to secure valid statistics, but in some directions better scientific results can be obtained by applying more careful methods to a limited number of cases. The difficulty in obtaining correct statistics is not the variable error, which decreases with the number of cases, but the constant errors, which can only be eliminated by proper methods. Thus, for example, I find that the parents of 871 scientific men had families of the average size of 4.65 children, with a probable error of 0.05. The chances are even that increasing indefinitely the number of cases would give a figure varying only between 4.6 and 4.7, and this is as close a determination as is needed. But a serious mistake would be made if it were assumed that the average family of the class from which the scientific men come were as large as 4.65. The fathers of 865 scientific men died at the average age of 70.6 years and their mothers at the average age of 70.2 years. The chances are even that this figure is correct within one third of a year, and this is all we need to know. It would, however, be incorrect to use these figures to prove that people of that class and generation lived to the age of seventy years or that the men lived longer than the women. In the census of 1880 there were found to be in the United States 170,000 more children in their second than in their first year. As over one tenth of all the children died in their first year, this result is incredible, and the large number of cases only makes the absurdity more obvious.

The table shows that of just one thousand leading scientific men for whom the information is at hand 105 are unmarried. 18 per cent.

TABLE IV. NUMBERS AND PERCENTAGES OF SCIENTIFIC MEN WHO ARE UNMARRIED IN ACCORDANCE WITH THEIR AGES

	Ages of Scientific Men					Total
	-39	40-49	50-59	60-69	-70	
Number......	150	402	269	131	48	1,000
Unmarried..	27	42	19	12	3	105
Per cent......	18.00	10.45	7.06	9.16	6.25	10.5

of those under 40 years of age are single, 10.5 per cent. of those between 40 and 50, and 7.5 per cent. of those over 50. According to the census of 1900, 17.1 per cent. of men 35 to 44 years old are single, 10.4 per cent. of those from 45 to 54, and 7.8 per cent. of those from 55 to 64. There is thus a tolerably close correspondence between the marriages of scientific men and of the general population, but the age groups of the census being five years older, a scientific man is more likely to be married than a man taken at random from the community. This is perhaps contrary to general opinion. A tradition of celibacy for the scholar has been inherited from the Roman Catholic Church, it being only within the time limits of these statistics that fellows of the colleges of the English universities have been permitted to marry. Professor Thorndike[1] found that only 12 per cent. of those in "Who's Who in America" over forty years of age are unmarried. On the other hand, President Eliot[2] found 28 per cent. of Harvard graduates 20 to 25 years out of college to be unmarried. There is a lack of satisfactory statistics of marriage conditions in different classes of the community. For different nations M. Bertillon[3] states the percentage of unmarried men over fifty years of age to vary from 16.3 in Belgium to 3.6 in Hungary, it being 7.5 in Germany and 10.1 in France.

Contrary to a wide-spread opinion, the marriage rate and the age at marriage have not varied considerably in the course of the past thirty years. The number of persons married annually for each thousand of the population in several countries has been as follows:[4]

	1881–1885	1910 (or 1909)
France	15	15.8
German Empire	15.4	15.5
Italy	16.1	15.5
England and Wales	15.2	15
Sweden	12.8	12

In England and Germany the rate was highest in the quinquennial period 1896–1900, reaching 16.1 and 18.8, respectively. The percentage of women between 15 and 49 years of age who are married has been:

	1880 (or 1881)	1900 (or 1901)
France	54.9	57.7
Italy	55.2	56.1
German Empire	51.9	52.8
England and Wales	51.4	49.2
Sweden	41.4	44.2

There has thus been no decrease in marriage corresponding to the decreasing birth rate which has occurred during this period. In France, where the birth rate is the lowest, the marriage rate and the percentage of women married are the highest.

The marriage rate varies from year to year with economic and social conditions, but the percentage of women of child-bearing age

1 "Marriage among Eminent Men," *The Popular Science Monthly*, 1902.

2 Annual Report of the President of Harvard College for 1901–02.

3 "La Dépopulation de la France," Paris, 1911.

4 Report of the Registrar-General (England and Wales) for 1910.

who are married proves that marriage is as usual now as it was a generation ago. The conditions, however, are extremely complicated, being influenced by birth rates, death rates, the age constitution of the people and immigration. The European nations with the exception of France have supplied great numbers of immigrants during the past thirty years; these are largely people of marriageable age with an excess of unmarried men. This circumstance makes it more significant that there has been no decrease in marriage in these nations. It explains in large measure the relations in France and England, the latter country having been left with an excess in its population of over a million women above fifteen years of age. The comparatively high birth rates and death rates of a generation ago, followed by the decreasing birth rates and death rates which have obtained in nearly all nations for the past forty years, give a large percentage of the population between twenty and forty years of age, and are favorable to a high marriage rate and to a large proportion of married people. It is significant of improved conditions regarding the health of married women that among 900 scientific men only 15 are stated to have children by a second wife and the number of children is only 29. The data also show that successive polygamy through divorce is unusual among scientific men.

TABLE V. AGES AT MARRIAGE AND THE SIZES OF FAMILY

Age......	15–19	20–24	25–29	30–34	35–39	40–	Av.	Med.
			Mother				22.88	22.29
Number..	85	229	99	21	6			
Size.......	5.56	4.90	4.47	2.71	2.50		4.74	
			Father				27.98	26.85
Number..	5	123	175	88	27	22		
Size.......	6.40	5.27	4.57	4.60	3.96	4.00	4.74	
			Wife				26.63	25.65
Number..	15	158	165	69	22	11		
Size.......	2.00	2.59	2.44	1.62	0.59	0	2.23	
			Scientific Man				29.50	28.40
Number..	2	67	196	108	39	28		
Size.......	2.00	2.27	2.56	2.14	1.62	1.18	2.23	

In Table V. data are given in regard to the age at marriage and the size of family of our leading scientific men and of their parents.[5] The

[5] The data are for the 440 cases in which the families of the scientific men were "completed" and in which there were no remarriages either of the scientific men or of their fathers. The families were taken as completed when the wife was 45 or older, when there had been ten years of married life without a child or when the period since the birth of the last child added to the mother's age is at least 45. Some of the families are then not absolutely completed, but the births would be very few. None of the 11 women who were more than 39 at marriage had children, although newly married women of this age are more

fathers married at the average age of 28 years and the mothers at the average age of 22.9 years. The median ages are naturally lower than the average ages, as màrriage can be postponed beyond the average longer than it can precede this average. The distribution of ages is also shown in the table. Five of the fathers and 85 of the mothers married under the age of twenty, 137 of the fathers and 27 of the mothers beyond the age of twenty-nine, 298 of the fathers and 328 of the mothers between twenty and twenty-nine. The scientific men themselves married at the average age of 29.5 years and their wives were on the average 26.6 years old. The sons married about one and a half years later than their fathers and their wives nearly four years later than the mothers. There is a statistical anomaly in this comparison, especially as regards the mothers, for women who married late would have few children or none, and the average age of the mothers would thus be reduced as compared with the wives. The differences are partly due to the fact that all the scientific men and only part of the fathers belong to the professional classes; and there has probably been an increase in the age of marriage of the professional classes in this country; but the figures show that any such increase must be small.

Bertillon gives the following figures for the average age at marriage in the period 1896–1900:

	First Marriages		All Marriages	
	Men	Women	Men	Women
England	26.6	25.1	28.4	26.2
France	27.9	23.5	29.6	25.2
Italy	27.5	23.8	29.8	24.8
Prussia	—	—	29.3	26.2
Austria	—	—	30.9	26.8
Sweden	28.7	26.7	30.2	27.2
Norway	29.2	27.2	31.0	28.1

The age of marriage is highest in the Scandinavian nations; it is lowest in the Sclave nations; it is as low in France, with its small birth rate, as elsewhere. In England in the case of first marriages the husband is one and a half years older than the wife, in France, nearly four and a half years older. The age of marriage for first marriages has increased in England by about three fourths of a year since 1896, before which date the registrar-general regards the records as inaccurate. The ages of the consorts at first marriages have increased from 26.59 and 25.08 in 1896 to 27.46 and 25.81 in 1911. The average age at which widowers marry has increased from 44.49 to 46.42; for widows from

likely than others to bear them. A larger error is due to the selection of families, as those having few or no children would be more likely to be completed. The 211 incomplete families have on the average 1.90 children, which is about the same as for the completed families of parents of the same age.

40.58 to 41.74. In the quinquennial period 1876–80, 7.8 per cent. of the husbands and 21.7 per cent. of the wives were under twenty-one, in 1911 these percentages had decreased to 3.9 and 13.3. The professional and well-to-do classes marry later than the average; thus in England, the ages of the men and women are, respectively, about 32 and 27 years, as compared with about 26 and 24.5 years for the artisan and laboring classes. It thus appears that American scientific men marry at a somewhat earlier age than the professional classes in England and their wives are of about the same age.

The table shows that the size of family of the parents of the scientific men—the fraternity of the scientific men—decreases decidedly as the age of the mother at marriage increases. It is about five and a half when the mother is under twenty; it decreases to four and a half when she is between twenty-five and thirty and to scarcely over two and a half when she is between thirty and forty. The decrease would be somewhat greater if barren marriages were included; but it is altered in the opposite direction by the fact that the larger family has the better chance of giving birth to the scientific man. The decrease in the size of family with the advancing age of the father is less, and depends mainly on the fact that older husbands are likely to have older wives. The age of the wife tends to increase about one year as the age of the husband increases by two years. According to the New South Wales statistics, admirably compiled by T. A. Coghlan,[6] the size of the family is five when the mother marries at 21, and as the age of marriage increases to 24, 28 and 32, the size of the family decreases to approximately four, three and two. In the case of the scientific men the family is 2.59 when the mother was 20 to 24 years old at marriage and 2.44 when she was 25 to 29. It is only two in the fifteen cases when she was under twenty. A comparison of these figures with those for the larger families of the preceding generation is significant, as they seem to show the condition when the family is small and limited. Under these circumstances there is but slight difference in the number of children when a woman marries at ages from 15 to 29. After thirty, however, there is a marked decrease, the size of family being 1.6 for women marrying between 30 and 34 and only 0.6 for those marrying between 35 and 39. Less than half of those marrying between 35 and 39 had children and none of those who married at the age of 40 or older had children.

The families from which our scientific men come had on the average 4.7 children, and those scientific men who are married and whose families are complete have on the average 2.3 children, these figures including all the children born. Sir Francis Galton[7] found that a

[6] "The Decline on the Birth Rate of New South Wales," Sydney, 1903.

[7] "English Men of Science," London and New York, 1875.

group of about 100 English scientific men (excluding barren marriages) had, on the average, 4.7 children, and their parents 6.3, and remarks: "This implies a diminution of fertility as compared with that of their parents, and confirms the common belief in the tendency to an extinction of the families of men who work hard with the brain." Mr. Havelock Ellis[8] found that 214 fertile marriages of British men of distinction produced, on the average, 5.45 children, while 276 "genius producing families" consisted, on the average, of 6.96 children, and remarks that "men of genius belong to families in which there is a high birth rate, a flaring up of procreative activity." He says further that this "might, indeed, have been anticipated. The mentally abnormal classes generally belong to families with a high birth rate"; and quotes data in regard to criminals and the insane. Thus two wide generalizations—that intellectual performance conduces to sterility and that genius is allied to insanity—are based on a curious statistical fallacy for which one would suppose Galton the least likely of men to be responsible.

In a population whose families remain of the same average size in successive generations, every one, whether he be a scientific man, a criminal or a tailor, is likely to come from a larger family than he has. If, for example, all families were of one or of seven children equally divided, the average family would be four in each generation, but the children would be seven times as likely to come from the larger family and would belong to a family which, on the average, would be 6.25. With an average family of three, the size of 100 families would be distributed approximately as follows:

Size of family	0	1	2	3	4	5	6	7	8	9	10
No. of families	18	10	20	22	13	6	4	3	2	1	1

When then we count up the average size of the family from which each of the 300 children come, it will be found to be 4.15. As our scientific men come from families of the average size of 4.7, one may conclude that the families of the class to which they belonged were of the average size of about 3.4. In one generation this family has been reduced to 2.3, owing either to a general fall in the birth rate or because scientific men have families which are smaller than those of the classes to which their parents belonged. Both factors are present; there is a general decrease in the birth rate and the educated classes have families smaller than the average.

In Table VI. is given information in regard to the sizes of family of the parents of scientific men in accordance with their nationalities and their occupations. The Germans had families of the average size of 5.7, the British of 4.8 and the native Americans of 4.5. The prob-

[8] "A Study of British Genius," London, 1904.

able errors show that these differences are not due to the limited number of cases. It is known that immigrants from foreign nations have larger families than native Americans, but these figures probably give the only information in regard to the families which produce scientific and other professional men. The disparity is not so great as in the so-called lower classes, but it is sufficient to indicate that in the professional classes descendants of recent immigrants from Germany and Great Britain will in part supplant the descendants of native Americans. It is, however, the case that immigrants are likely to become assimilated to native Americans in size of family as well as in other respects.

TABLE VI. THE SIZES OF FAMILY OF THE PARENTS OF SCIENTIFIC MEN IN ACCORDANCE WITH THEIR NATIONALITIES AND THEIR OCCUPATIONS

	No.		Size	
American	625		4.45	
British	131		4.83	
German	67.5		5.73	
Others	47.5		5.20	
Total	871		4.65	
Professions		381		4.51
Clergymen	88		4.77	
Physicians	65		4.22	
Lawyers	60		4.58	
Teachers	75		4.39	
Others	93		4.54	
Agriculture		185		5.09
Manufacturing and trade		311		4.59
Total		877		4.66

The parents of scientific men from the agricultural classes had families of the average size of 5, those engaged in manufactures and trade of 4.6 and those in the professions of 4.5. It was shown in the previous article that the agricultural classes contribute in proportion to their numbers only one thirtieth as many scientific men as the professional classes, and this disparity is increased by their larger families. Among the professions, physicians had the smallest families and clergymen the largest, but the differences are not large, the family of the clergyman being smaller than the family of the farmer. These figures do not, of course, give information in regard to families of the present generation, in which the differences are probably greater.

TABLE VII. THE SIZES OF THE FAMILIES OF THE SCIENTIFIC MEN IN ACCORDANCE WITH THEIR NATIONALITIES

	No.	Size
American	544	2.19
British	49	2.43
German	19	3.21
Others	17	1.88
Total	629	2.23

In Table VII. are given the figures for the children of the scientific men in accordance with their nationalities. The Americans have, on the average, a family of 2.19 children, the British of 2.43 and the Germans of 3.21. The German family is thus nearly 50 per cent. larger than the American. The number of foreign families is, however, too small to give valid averages. It would be very desirable to obtain information in regard to the size of family and other vital statistics for dif-

ferent nationalities and social classes in our population. A single expert in the Bureau of the Census could collect and collate such data in the course of a couple of years at insignificant expense.

Table VIII. gives the sizes of the families from which the scientific men have come and which they have in accordance with the geographical division in which they were born and in accordance with whether they

TABLE VIII. THE SIZES OF THE FAMILIES FROM WHICH THE SCIENTIFIC MEN COME (THEIR FRATERNITIES) AND WHICH THEY HAVE (THEIR CHILDREN), IN ACCORDANCE WITH THE REGION OF THEIR BIRTH AND WHETHER BORN IN THE CITY OR IN THE COUNTRY

Divisions	Country Born			City Born			Total		
	No.	Fr.	Ch.	No.	Fr.	Ch.	No.	Fr.	Ch.
North Atlantic......	206	4.40	2.34	124	4.18	2.22	330	4.32	2.29
South Atlantic......	17	4.53	2.29	17	5.12	2.18	34	4.82	2.24
South Central........	7	5.71	2.86	5	3.80	4.40	12	4.92	3.50
North Central.......	151	4.99	2.17	44	4.75	1.77	195	4.94	2.09
Western...............	5	6.00	4.00	5	6.20	1.60	10	6.10	2.80
Total................	386	4.68	2.31	195	4.43	2.15	581	4.60	2.25

were born in the country or in the city. The differences are small. When the parents lived in the country or in small places at the time of birth of the scientific man, they had on the average 4.68 children; and when they lived in towns which in 1900 had a population of 25,000 or over, the size of family was 4.6. The scientific men born in the country had on the average 2.31 children, those born in towns, 2.15. As it will take a long time to correct the common idea that children born in the country are more likely to attain success and distinction than those born in cities, attention may again be called to the fact that 34 per cent. of these leading scientific men were born in cities having in 1860 about 12 per cent. of the population of the country. The greater productivity of cities in men of distinction is doubtless in part due to the fact that the abler and more enterprising people are drawn from the country to the cities, their children inheriting superior ability, and in part to the fact that the city-born children have an environment more favorable to education and to success in scientific work.

The number of families from the southern and western states is too small to give reliable information in regard to the number of children. The fraternities of the scientific men from the North Central States are larger than of those from the North Atlantic States, but their own families are smaller. The differences are small, but apparently significant. The scientific men born in the North Central States came from families of 4.9 and had families of 2.1, those from the North Atlantic States came from families of 4.3 and had families of 2.3. A generation ago the families of the Central States—at least those of tl

particular class—were larger than those of the Northeastern States; they are now slightly smaller. The fertile and wealthy state of Iowa had a smaller population in 1910 than in 1900. The increase in the population of the country is maintained by immigrants and the children of immigrants. The 87 scientific men born in Massachusetts had fraternities of 4.1 and families of 2.1 children, the 117 born in New York State had fraternities of 4.5 and families of 2.3 children.

The table shows the great preponderance of the North Atlantic and North Central States in the production of scientific men and the infertility of the south, concerning which statistics have been given by the writer in previous articles. The birth rate of leading scientific men per million of the population has been 107 in Massachusetts, 89 in Connecticut, 47 in New York, 23 in Pennsylvania, 32 in Ohio, 36 in Michigan, 45 in Wisconsin, 24 in Illinois, 12 in Missouri, 9 in Virginia, 5 in North Carolina, 3 in Georgia, 2 in Alabama, 1 in Mississippi and Louisiana. In recent years, however, the North Central States have been gaining and the North Atlantic States have been relatively losing. Thus for younger men the birth rates in figures comparable to those given above have fallen to 85 in Massachusetts, 57 in Connecticut and 36 in New York, whereas they have risen to 35 in Ohio, 74 in Michigan and 54 in Wisconsin. These differences and changes the writer is disposed to attribute in the main to environment rather than to heredity. From the family stocks of Massachusetts, Michigan or Louisiana, we can obtain as many competent scientific men as we care to educate and support.

TABLE IX. THE SIZES OF THE FRATERNITIES AND FAMILIES OF THE SCIENTIFIC MEN IN ACCORDANCE WITH THE INSTITUTION AT WHICH THEY ARE EMPLOYED

	No.	Fr.	Ch.
Larger universities	242	4.50	2.18
Smaller state institutions	89	5.04	2.62
Smaller private institutions	122	4.69	2.29
U. S. government	73	4.64	2.00
Commercial and private	61	4.72	2.44
Research laboratories, etc.	56	4.52	2.41
Total	643	4.65	2.28

The distribution of the families among different kinds of institutions is given in Table IX. The fraternities of the scientific men are substantially the same in all cases. The only instance in which the departure from the average exceeds the probable error is for the smaller state-supported institutions, and the difference here may not be significant. In the case of the children of the scientific men, the size of family is probably influenced by the environment. The 61 men in the government service, most of whom live in Washington, have the smallest

families, those in the smaller state-supported institutions the largest. The probable errors of the figures are about 0.1, so the differences are not likely to be due to chance. The 61 men in commercial work, or having no institutional affiliations, and the 56 men in research and related institutions have families larger than the average, while those in the larger universities have families smaller than the average. In the larger private universities the situation, for those with 10 or more professors who supplied the information, is: Harvard, 42 families with an average of 2.2 children; Yale, 16 and 2.0; Chicago, 25 and 2.1; Johns Hopkins 12 and 2.1; Cornell, 29 and 2.3; Stanford, 13 and 2.4; Princeton, 10 and 2.5; Pennsylvania, 13 and 2.5; Columbia, 25 and 2.7. The smallest families are at Yale, Johns Hopkins and Chicago, the largest at Princeton, Pennsylvania and Columbia. The larger state universities have professors with the smallest families, the size of family being Michigan, 17 families with an average of 2.1 children; Minnesota, 10 and 1.8; Wisconsin, 15 and 1.7; Illinois, 15 and 1.6.

The figures given are for completed families and for all children born. The death rate for the children of scientific men is unusually small, 75 per thousand to the age of five years and about 120 to the age of marriage. The marriage rate for scientific men is high, 895 among the thousand being married. None the less it is obvious that the families are not self-perpetuating. The scientific men under fifty, of whom there are 261 with completed families, have on the average 1.88 children, about 12 per cent. of whom die before the age of marriage. What proportion will marry we do not know; but only about 75 per cent. of Harvard and Yale graduates marry; only 50 per cent. of the graduates of colleges for women marry. A scientific man has on the average about seven tenths of an adult son. If three fourths of his sons and grandsons marry and their families continue to be of the same size, a thousand scientific men will leave about 350 grandsons who marry to transmit their names and their hereditary traits. The extermination will be still more rapid in female lines.

If the families of the scientific men should increase at the rate of the general population, the thousand leading scientific men would have some 6,000 grandchildren instead of fewer than 2,000. These well-endowed and well-placed people would probably have an average economic worth through their performance of not less than $100,000, and the money loss due to their non-existence is thus $400,000,000. The loss to the welfare of the nation and the world from the suppression of the social traditions and the germplasm is incalculable. Until democratic society learns that services for society must be paid for by society, and that the two most important services are scientific research and the bearing and rearing of children, the universities, on which three fourths of our scientific men depend for support, have great responsibilities.

They to a certain extent profess that research is part of the work for which their professors are paid, but they do not acknowledge a similar obligation in regard to the children of professors. Columbia University gives, under certain faculties, scholarships to the sons of professors; Yale University has had a statute by which a married professor received a slightly increased salary; the provisions of the Carnegie Foundation benefit married professors. But these are slight acknowledgments of the obligations of our universities.

President Eliot tells us that "the welfare of the family is the ultimate end of all industry, trade, education and government"; but, in his book on "University Administration," he writes:[9]

> The general features of a good scale of salaries are as follows: The salary of an annual appointee at the start should be low, about the amount needed by a young unmarried man for comfortable support in the university's city or village. When, after a few years, this young man receives an appointment without limit of time, a somewhat higher salary should be given him, with a small advance each year for, say, three years. If this instructor so commends himself that the university desires his further service, he should receive, as assistant professor, a salary which will enable him to support a wife and two or three children comfortably, but without luxury or costly pleasures.

The scientific man receives his doctorate at the average age of twenty-seven years and is then eligible for an instructorship with a salary for an "unmarried man"; after "a few years" and then "three years" more he is to receive a salary which will enable him to support "two or three children." President Eliot also says:

> The recent tendency of sons of well-to-do, and even rich, families, to go into the ministry, the medical profession, academic life, and the public service, is one in which all patriots may well rejoice. . . . It is a good deal safer to give a life office to a married man on whom marriage has proved to have a good effect, than to a single man who may shortly be married with uncertain results.

There might well be inscribed at Harvard and at other universities the words which President Eliot wrote for the Water-Gate of the Chicago World's Fair, changing one word, so that it would read:

TO THE

BRAVE WOMEN

WHO IN

UNIVERSITIES

AMID STRANGE

DANGERS AND

HEAVY TOIL

REARED FAMILIES

AND MADE HOMES

The vital statistics of the United States are entirely inadequate. Where registrations of deaths and births exist, they are imperfect, and the changing population, its age composition and the amount of immigration render them difficult to interpret. The only information concerning birth rates is given by the proportion of children as determined by the census,[10] but even this is unreliable. It might be supposed that it would be possible to determine the number of children by counting them, but this is not the case. The children reported in the census of 1850 were fewer than the survivors (with the comparatively small excess of immigrants) counted ten years later. There are always more children given as two years old than as one—in 1880 as many as 170,000 more. Nor can we have complete confidence in the compilations of the experts of the census. Thus in the case under consideration they give[11] figures showing that the white population of the United States increased from 1790 to 1800 by 35.7 per cent., adults over 20 by 50.9 per cent., and children under 16 by 38.8 per cent., whence it follows that children from 15 to 19 decreased 22 per cent. This is of course absurd and is due to a gross error of some sort. However, the ratio of white adults twenty years of age and over to white children under 16, according to the census reports, is shown on the curve. The percentage of children under 16 years of age in the white population increased from 1790 to 1810 and was the same in 1820 as in 1790. In 1810 just half the white population consisted of children under 16; in 1900 the percentage of children had decreased to 35.7.

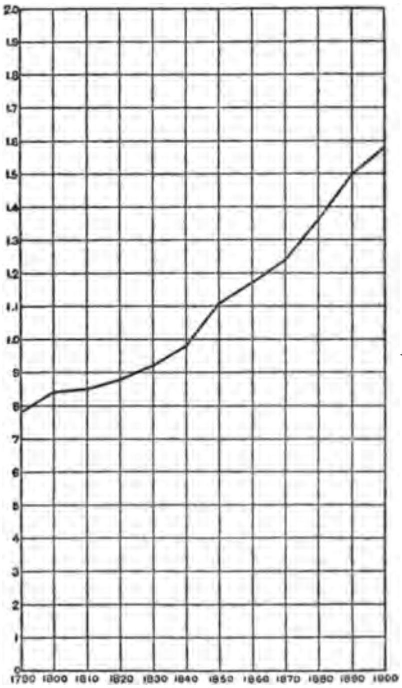


FIG. 1. RATES OF WHITE ADULTS OF SELF-SUPPORTING AGE TO WHITE CHILDREN UNDER SIXTEEN YEARS IN THE UNITED STATES, according to the Bureau of the Census.

[10] In January, 1917, was issued the first bulletin from the Bureau of the Census giving birth rates for ten states.

[11] "A Century of Population and Growth," Bureau of the Census, 1909, pp. 80 and 103. An answer to a letter addressed by the writer to the director of the census partly explains the way this error was committed—but the explanation was marked "confidential"! It is, however, no violation of this confidence to state, as the information is available from official reports, that figures were not at hand prior to 1830 and that these were guessed—it appears very awkwardly—so as to give a regular curve.

From a special study by Mr. Kuczynski,[12] it appears that the birth rate of the native population of Massachusetts has been 63 per thousand women of child-bearing age, as compared with 85 in France, 104 in England and 143 in Russia. Its birth rate per thousand of the population was 17, the size of family 2.61 and of the surviving family 1.92. Special statistics have been gathered for college graduates. President Eliot in his report for 1901–02 stated that 634 married Harvard graduates of the classes from '72 to '77 had an average family of 1.99 sur-

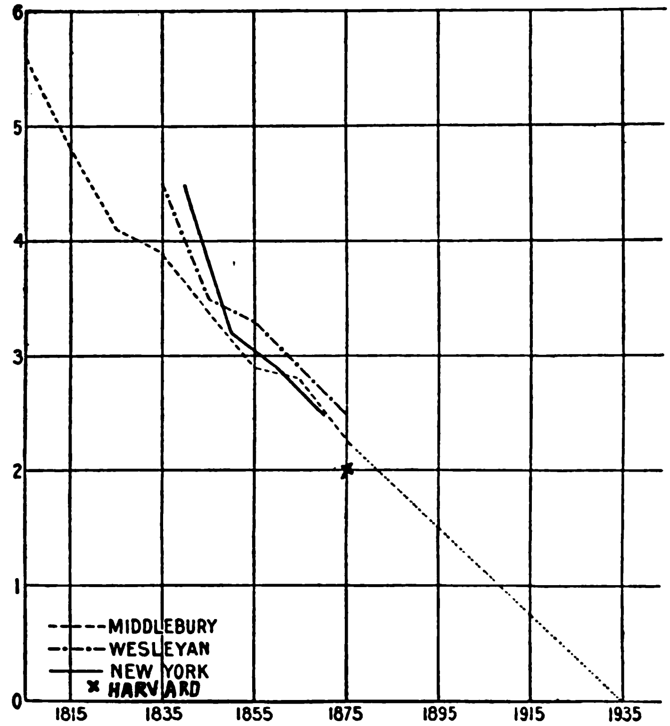


FIG. 2. THE DECREASE IN THE SIZE OF FAMILY OF COLLEGE GRADUATES.

viving children. Only 71.9 per cent. of the graduates were married, and the number of children for each member of the class was 1.43. If only 72 per cent. of Harvard graduates are married at the average age of fifty, it is a serious indictment of the kind of men who go to Harvard or of the influences under which they come. We have seen that 91 per cent. of American men of science over 40 are married. Other data concerning the families of college graduates have been published by Professor Thorndike[13] and others.

Curves are here drawn for some of the data, which show that the

[12] *Quarterly Journal of Economics*, November, 1901, and February, 1902.

[13] "The Decrease in the Size of American Families," Edward L. Thorndike, *Popular Science Monthly*, 1903.

gross size of the family of college graduates has decreased from 5.6 at the beginning of the century to 2.5 for classes graduating in 1875, while at that time the size for Harvard was about 2. A projection of these curves—which of course gives no scientific information—shows the curious result that if the decrease should continue at the same rate students graduating in 1835 would have no children. The average college graduate has a family of about the same size as the scientific man of the same age. Data collected for the graduates of Yale,[14] in the classes 1869–86 twenty years after graduation and thus not quite complete, give the following results for different occupations:

Occupation	Marriages	Family
Clergy	119	2.2
Law	398	2.0
Education	163	2.0
Manufacturing	88	2.0
Medicine	108	1.7
Merchant	82	1.7
Miscellaneous	258	1.9

Graduates of colleges for women also have had families of about two, but half of them remain unmarried. The Harvard graduate thus has on the average three fourths of a son, the Vassar graduate one half a daughter.

Since this article was written and published in abstract elsewhere,[15] there have appeared two excellent articles on the size of family of college graduates. Johnson and Stutzmann[16] find that about half of Wellesley College alumnæ graduating from 1879 to 1888 married and had families averaging 1.56 children. John C. Phillips[17] gives data from the class reports of Harvard and Yale students compiled twenty-five years after graduation. Seventy-four per cent. of Harvard graduates and 78 per cent. of Yale graduates had married. The number of children born for each married graduate decreases from about 3 in the fifties to 1.8 in 1890. As Mr. Phillips points out, the decrease becomes slower between 1875 and 1890.

TABLE X. THE SIZES OF THE FAMILIES IN ACCORDANCE WITH THE EDUCATION OF THE MOTHER

	College	Partial	None	Total
Under 50				
No.	109	33	119	261
Size	1.81	1.79	1.98	1.88
50 to 59				
No.	58	20	145	223
Size	2.22	2.20	2.39	2.33
Above 59				
No.	21	7	117	145
Size	2.57	3.43	2.69	2.71
Total				
No.	188	60	381	629
Size	2.02	2.12	2.35	2.23

In Table X. it is shown that the families of scientific men in which the mothers have had a college education are not appreciably smaller than others. If one regards only the total, it appears that when the mother had a college education the aver-

14 *Yale Alumni Weekly*, 1907.

15 Proceedings of the First National Conference on Race Betterment, uary, 1914; *The Independent*, September 17, 1915.

16 *Journal of Heredity*, 1915.

17 *Harvard Graduates Magazine*, September, 1916.

age family is about 2, when she had a partial college education 2.1 and when she had none 2.3, but these differences are chiefly and probably entirely due to the fact that the younger scientific men have the smaller families and at the same time are more likely to marry college graduates. If we divide the scientific men into three age groups, the differences become much less, and if the groups were subdivided still further they would probably disappear. This illustrates the possibility of statistical fallacies when a group is not homogeneous. Of the scientific men under fifty, 109 married college graduates and had families of the average size of 1.81, 33 married women with a normal school or partial college education and the average family was 1.79, 119 married women without a college education and the average family was 1.98. 54 per cent. of scientific men under 50 have married women with a college education; for scientific men from 50 to 59 the percentage falls to 35 and for those 60 or older to 19.

The figures result not only from the increasing numbers of women undergoing higher education, but also from an extension of common scientific interests and pursuits for men and women. A distinguished biologist has observed that "if marriages are made in heaven, Woods Hole may be regarded as a branch office." To the same biologist we owe the remark that "eugenics is an infant industry." There is truth in both epigrams. The percentage of men who have married women with whom they have been thrown into association as teachers or fellow students is large, and we are at present ignorant of the results of such marriages. Small as are the families of scientific men, it is here shown that they are not so because the mother is a college graduate. If both mother and father have common scientific aptitudes and interests, the physical heredity and social traditions should lead the children to follow similar scientific pursuits with an early start and favorable opportunities. I shall be able to give the percentage of fathers and sons, or of two or more brothers, who have engaged in scientific work, and it may be possible to determine the effect when the mother also has scientific interests and ability.

(*To be continued*)

THE FUNDAMENTAL NATURE OF POPULATION

By PROFESSOR SPENCER TROTTER
SWARTHMORE COLLEGE

I

A MAN'S thoughts and activities are so much a part of his temperament, and this again so much a matter of inheritance, and the whole man so much a product of his surroundings, that the "feelings" he experiences and the "things" he does can hardly be said to originate within himself. Aside from the purely subjective sensations of hunger, desire, fatigue and the sense of ill, or well-being, the feelings of a man may be said to originate from without—to be objective—a result of the impress made upon him by the surrounding world of men and things. Likewise, what a man does, his actions and their furtherance in work, arising from these various feelings, can no more be said to originate in him than the feelings which prompted him to do thus and so. In other words, a man is seen as the sum of his inherited traits plus his surrounding conditions. These set the pace for him, thwarting him here, driving him to results there, encompassing him with limitations or sending him through some loophole of opportunity.

The succession of events that makes up the active life of any individual thus resolves itself into a matter of "feeling" and "doing," or, reduced to physiological terms, of *sense* and *action*. Structurally this involves a *sensori-motor mechanism* in the individual, a complex of nerve fibers which transmit impulses received from the various sorts of stimuli that arise from the energy of the outside world through the mediation of certain peculiar nerve-end structures (special sense-organs) to groups of centrally located nerve-cells (brain and spinal cord ganglia) which receive these sensory impulses, and, as a result of molecular changes induced in their living matter or protoplasm, send out impulses along motor nerve tracts to muscle, gland or other structure thus innervated.

We can only surmise as to the nature of a nervous impulse. It is reasonably certain, however, that the transit of an impulse along a nerve fiber and its modification in the cell-substance involves changes in the positions of those innumerable molecules that form the physical basis of all material things. And likewise the changes brought about in a sensory organ, whereby a raw stimulus of the outer world stirs the

nerve ends into transmitting impulses perceived as light, or sound, smell, taste or touch, as the case may be, are also molecular in their nature. It matters little what the character of the impulse is, all are probably transmitted in much the same fashion; it is in the discriminating quality or function of the cell substance at the central end, in the brain, that determines the difference. Whether it be sight or sound is not then so much a matter of nerve fiber or of eye or ear, but lies in the fact that the special nature of the central cell substance in that particular part of the brain to which the impulse is transmitted is impressed by only one sort of impulse—that of light or that of sound. As William James puts it hypothetically, if the optic nerve could be spliced on to the nerve of hearing so that an impulse generated in the retina by the physical stimulus of light was thus switched off to the auditory area in the temporal lobe of the brain, and at the same time the visual area of the brain brought into connection with the end organ in the ear, we should then hear lightning and see thunder.

The molecular change involved in the passage of an impulse from the central cell along a motor fiber to a muscle is quite likely of the same nature as the sensory impulse, only it is outgoing instead of incoming and its results are peripheral—the liberation of a vast amount of energy in a muscle fiber causing its contraction with a consequent display of motor activity. The probable nature of this molecular change in nervous matter was illustrated by the late William Kingdon Clifford as a tipping or falling over of one molecule against another, much as a row of blocks or cards set upright would fall over against one another, starting a motion that traveled along the whole line, upsetting the positions of molecules in the central substance which imparted a like motion outward along a motor nerve. Such an illustration is helpful in getting some idea as to how a nerve impulse travels. It should not, however, be construed into an explanation of the ultimate nature of a process which can not be demonstrated, only inferred.

The brain, with its discriminating faculty in regard to sensory impulses flowing in from the outer world and its transmission of these effects into motor impulses, is thus the real criterion in the life of an individual. And furthermore, certain of its structures have, by the peculiar nature of their molecular substance and by their connection through association fibers with various centers of impression, developed a memorial faculty and a faculty of imagery which enter into that complex life of the mind where purposive functions, judgment, volition and consciousness—all that we comprehend as intelligence—have free play.

The various activities involved in this sensori-motor mechanism of the individual imply a continual loss of substance, a waste of material that is made good from time to time through food and rest. Whatever

the life-force or vital principle may be in ultimate analysis, it is apparently bound up with the chemistry of oxidation or combustion. Waste and repair are always the accompanying terms of the process, and the tangible products of this loss of substance are water and carbon dioxide. Living matter itself, in ultimate analysis, appears as a combination of four main elements—carbon, hydrogen, oxygen and nitrogen—and of these four the last one named seemingly holds the master key of all vital processes. Whatever else a molecule of living matter may contain, nitrogen is always one of its constituents. Without the presence of this element there is no life. The actual part that it plays in the combination of an active, living molecule is certainly not known. Oxygen does not combine with it in those destructive processes that appear to energize the molecule. Its rôle seems to be connected in some way, as yet little understood, with the constructive processes of life, enabling the molecule to assimilate the reparative elements in food.

Throughout the entire world of animals and plants the basic processes of life are the same. These two forms though they pursue the same ends, by the same means, in nutrition, growth and reproduction, yet each has its distinct rôle in the conservation of universal energy—the one kinetic (energy in motion), the other potential (energy at rest). This is the sole reason for the existence of each, and this, too, is the reason for their difference. In the world of green plants the molecules of waste from the activities of animal life are split up into their component atoms and again recombined into molecules of more complex and less stable constitution, as starch, sugar and the protein compounds. This is accomplished by the chlorophyll or green coloring matter of the leaves and other green parts through the influence of the actinic or ultra-violet rays of sunlight. These unstable substances are potential by virtue of their instability, and when taken into the animal body as food their energy is liberated by the destructive process of oxidation and becomes kinetic, at the same time breaking down into the simpler, more stable molecules of water (H_2O), carbon dioxide (CO_2) and ammonia (NH_3), which are again taken up by the world of green plants.

Life is thus under the same compelling forces that dominate the matter of the world at large. The plant finds its counterpart in the energy stored up in the impounded water of a lake or reservoir which when liberated by the opening of flood-gates pours forth under the influence of gravity and manifests its energy, like the animal, in various ways along its course. Reaching the ocean, these water molecules are lifted up by the heat rays of the sun and drifting over the hills as clouds fall in showers of rain to replenish the waters of the highland springs and lakes from which the rivers flow.

Certain processes of animal life as nutrition, respiration, growth and

reproduction, are akin to these same processes in plants and may be regarded as *vegetative* in contrast to the purely kinetic manifestations of the sensori-motor mechanism which are distinctly *animal.*

II

The deep stream of racial life appears in each individual, not only in its somatic or bodily manifestations, but as a well-spring of impulse that underlies consciousness—the subconscious or subliminal self. It is in this field of the subconscious that the reactions of the individual as a unit of population are most manifest, those reactions that are instinctive in the life of a race and that endure from generation to generation. The whole complex of social sentiments is of this racial subconscious quality. The individual acts in this respect not as a "free agent," but as an integral part of the whole body of population. Consciously he may "think for himself"; subconsciously or instinctively he reacts as the social sentiment determines. This social sentiment may appear as ephemeral and only of the moment, or as an uprising of the deep racial stream. In either case it has its origin, not in any individual consciousness, but in the subconscious flow that permeates the whole mass of population.

This unity of individual and population is fundamental and results from the nature of life itself. The nutritive processes of the individual are concerned not only with his maintenance, but with his growth as well. A definite expenditure of energy is required in the formation and development of an individual and in the processes of somatic or bodily growth to bring the organisms up to a certain physiological point—that of potential reproduction. At this point somatic growth, through a surplus of energy, expands beyond the limits of the individual organism into the growth of the body politic. Population is thus a continuance of individual growth; both are the results of the same process—the formation of units from preexisting units through growth. Reproduction is only an expanded phase of the growth of the individual. Carried into the higher nervous centers this fundamental growth process expresses itself in two closely related phases of individual existence—the *food quest* and the *sex impulse;* the first intimately concerned with the individual maintenance, the last with the maintenance of the race and of population.

Population as it presents itself to an observer, is to be regarded as any point in the flow of those hereditary qualities that constitute race or species. It is a momentary view-point of the great currents of human life; here flowing in separate channels of diverse features; now mingling in some deep settling-pool, some center of mixing populations, later to flow out as the current of a historic stream; again and again receiving a depressing or an invigorating tributary from other channels of the vast flow, its whole mass continually changing and still holding some of the original qualities of its fountain-head.

III

The vast assemblage of floating life that peoples the ocean world, its varied forms more or less submerged and drifting aimlessly in the set of wind and current, has received the comprehensive name of the *plankton.* It is distinctively the floating life (*plagtos,* wandering), and embraces, among other forms, those multitudes of minute, unicellular organisms which probably have existed in the primordial sea since its beginning as a sea, and from which all the other beings of the world have been evolved. This primitive ocean environment has left its mark on the higher life, on creatures that emerged from the plankton and after countless ages found an abiding place on the land. This needs no further comment, no more than does the equally familiar fact that each and every individual starts its existence as a unicellular organism similar in its detail of structure to those microscopic units of the plankton. The unity of life is expressed not only in this simple, fundamental mode of beginning in all individuals, but likewise in a variety of other ways. As the units of the plankton are immersed in an enviroment of sea-water from which each draws the food and oxygen necessary to its existence and its activities, so those tissue units, the cells, which form the ultimate structural basis of the bodies of all animals and plants above the Protozoa and Protophyta, are bathed in the watery lymph that soaks out from the main currents of the blood, rich in food and oxygen. This relational feature between the plankton elements out of which all life has arisen and the structural elements of more highly organized bodies, appears to bear on its face more than a mere parallelism. It is rather of the nature of a transcendent hereditary link, a stamp, as it were, of ultimate origin, the same relational conditions persisting between organism and environment from the beginning. In fact, it could not be otherwise, for the events in the developmental process are but the expansion and elaboration of an original and fundamental relation between life and its environment. The freely moving plankton element becomes later a unit in the aggregation of more fixed elements in the body of polyp, medusa or sponge into which the water must circulate to bring the required food. In the still more complex structure of higher organisms the water becomes incorporate in the tissues as blood and lymph. In its simplest form, as in the sponge body or the polyp, the immersing water is drawn through a mouth-like opening into a space or cavity, the most primitive type of digestive sac or canal, where the digestive and circulatory functions have not as yet been divorced. In further stages of evolutionary advance the circulatory scheme becomes more or less separated from the digestive area and distinct systems thus arise. In this circulatory medium or blood many primitive unicellular bodies, the leucocytes or white corpuscles are afloat, a veritable plankton within the organism.

This unity of all living forms is again apparent in the ultimate nature of the reproductive increase of individuals by the process of dividing units. It is conceivable that the entire plankton arose in this way from some archaic mass of living matter endowed with the energy to divide its substance. And this is the only method of increase throughout the whole realm of life from the lowest and most simple to the highest and most complex—each and all start from a single unit with the potentiality to divide its matter into innumerable other units. In the plankton protozoa these resulting units always remain segregate and free entities, but in all the forms above these there is a holding together of the units, an aggregate of the entities that have been formed by the division of the primitive cell unit or ovum. Out of this aggregate the animal or the plant body is fashioned. While the simple plankton unit (amœba, foraminifer, or other form) reacts under the stimulus of environment, utilizing food material and oxygen and dividing itself into like units, the units that become aggregate to form the bodies of higher organisms lose more or less of this ability to live each unto itself. They become dependent one upon the other, and here the principle of organization becomes apparent, and that remarkable law of the division of labor whereby certain sets or groups of units are told off for some line of work in which they have become specialized and supreme at the expense of all the other functions. Organization, then, may be said to proceed by the relegation of the individual units to specialized labor for the good of the whole.

Of the several groups of organs arising by this division of labor that of the nervous system is the one most peculiar and distinctive of the animal body. The irritability and general response to outside stimuli that is exhibited by the living substance of primitive, unicellular beings is in the higher forms perfected into an elaborate sensorimotor group of tissues through the principle of organization. Its structural beginning is in the outermost of the two elemental tissue layers—the ectoderm—and this is significant, inasmuch as this ectoderm is the contact layer of cell units, the one directly in touch with the environing media. Out of the substance of these units is spun the web of cell and thread that links the animal with its world. This nervous matter appears of an innately "purposive" and "memorial" nature, in that bodily form and structure are modified under its influence and many sorts of stimuli, caught up from the surrounding world, are indelibly impressed and retained. The resulting responses of the organism to the environment thus become instinctive reactions.

The ancestral type of vertebrate animal undoubtedly existed in a form similar to, if not identical with, the amphioxus, which in all probability emerged from some line akin to the segmented worms with a peculiar specialization of the structures enveloping the central nerv-

ous system and intimately associated with its development. The drifting forms of the plankton are eminently pelagic (of the open sea) and represented by the lower and more primitive types. Where the ocean laps over the continental shelf, as increasingly shoal water to the littoral, another mode of life becomes more or less characteristic—that of the *Benthos,* or forms that have developed either a fixed habit of life like the polyps and the crinoids, or those whose locomotory apparatus is adapted to slow crawling and creeping movements on the sea bottom or to burrowing in the sands and mud. The origin of the vertebrate type is thus distinctly related to this mode of life since amphioxus finds its habitat in the waters and sands of the littoral. Thus viewed, the vertebrates appear as a result of the process of continental uplift, the earliest environment of the primitive type being the marginal zone of sea.

The paramount fact in the development of the vertebrate is the central nervous system, the advance through its several genetic types—fish, amphibian, reptile and mammal—being in the increasing complexity and relative enlargement of the brain structure. This development is carried up through the mammal until it emerges in man as the one supreme organ of existence, the functioning of which has carried the type immeasurably beyond the limits of the material organic world.

The notable fact in this phenomenon of the human brain is that it has arisen, as have all other organs, by an infinitely long and slow process of development from the lowest vertebrate type of central nervous structure, and beyond this again from ganglionic masses of nerve cells which had more or less of a distinctive control of each form, throughout the whole line of descent, becoming simpler and less defined structurally until it disappears in the general diffuse irritability of some plankton protozoan. What is known as the "fundamental law of biogenesis," whereby each individual recapitulates the successive stages of development through which its ancestors have passed, must be as true of the brain as of other structures. It seems probable, therefore, that the brain of man, in common with the brains of many other animals, possesses certain fundamental endowments which have been derived from primitive types. This must find expression in certain distinctive reactions which are not only individual in the limited sense, but are worked out as a part of the individual's subconscious or instinctive life in relation to the whole mass of individuals of the species which constitutes population.

IV

What I wish to make clear in this thesis is (1) that the phenomenon of human population and of the human social state is not the result of any particular human faculty, but is consequent upon the fact that

the human brain is an integral part of the world of animal life. (2) That human society is an organism made up of diverse units and is the product of the same forces and processes which have produced the bodies of individual organisms. (3) That the brain units or cells in man have instinctive reactions toward organization, as a result of their descent from plankton units, the protoplasm of which possessed the same tendency that resulted in the formation of the primitive animal body. The law of the division of labor is operative alike in the formation of the bodily organism and the social organism. In certain hydroid polyp stocks it is a question whether the branched colony should be regarded as an individual and its component zooids, both nutritive and generative, as organs developed under this law of the division of labor, or whether each zooid is an individual united with other individuals into an organized community. The point lies in what we are to regard as an individual, or as defining an organ. Indeed, it seems quite probable that in such a type the terms "individual" and "organ" might be taken as meaning one and the same thing. It is no mere haphazard expression, this extended use of the term "organization," both as to the bodily structure of the animal and the social structure of population. Each alike has arisen from the same basic principle inherent in living matter.

The tendency of units to form aggregations is seen in many groups of lower animals; the social insects, as ants, bees and wasps; the flocking of birds and the nesting communities of many species; the vast "schools" of various kinds of fishes, and the "herd instinct" among the antelopes, deer, cattle and other mammals. We see in all this the instinct to draw together for mutual advantage and protection, but being instinctive, it is unconscious, not in any sense an individual act in itself. It is an expression of a primitive function of living matter carried up and working out through the living matter of brain cells which are as much aggregates of units as the floating masses of the plankton. Human population rests on this same fundamental biological fact. This, I am aware, has been frequently pointed out by both biologists and sociologists, and yet, I am sure, it will bear a further analysis.

Various features relating to the individual, as the comparative anatomy of parts, the significance of vestigial structures and of embryonic characters, certain atavistic tendencies in childhood, problems of a physiological nature and numerous instinctive reactions, have been dealt with at length by biologists and anthropologists as proof of the animal nature and origin of man. The question of population as an organism that has developed from the same basic principles and under the same laws as other organisms has not, however, received as much attention. Certain institutions, for example, which on their face are apparently of entirely human origin and in nowise related to the lower world of ani-

mal life, have, nevertheless, arisen solely as the result of this principle of organization, inherent in brain cells, from an ancestry of lower types.

The activities of the animal center about the two dominant functions of reproduction and the acquirement and the appropriation of food. Population, in ultimate analysis, is busied about the same affairs, and the expansion of the organizing principle appears in the exploitation of natural resources and in trade. No matter how far removed the activities of business may seem from anything that pertains to the natural conditions of animal existence, they are fundamentally related to just these two primary factors of life—food and sex. In like manner the other seemingly purely human manifestations—social relations, government, and all that pertains to these, are organized powers for furthering the food and the reproductive relations of the species.

As Ratzel has remarked, it is no accidental simile that the word "culture" is used to indicate the acquirement of a certain power in the use of various outside contrivances for furthering existence other than those endowed by nature; for it is the direct outcome of the very root of a population's energies—"agriculture." Here is an organization of powers directed toward increasing the food supply through that great basis of resource—the soil. All life, both plant and animal, is directly related to soil, and in exploiting it man is only increasing its potential energy as a source of food. Intelligence is at basis the organization of brain cells directed primarily to this end of soil culture, and the degree of a population's advance, or its state of culture, is directly proportional to its ability to get the largest yield per capita of food plants from a clod of earth. A people that has thus cultivated the soil up to its limit of production, so that it yields just the full amount of food required to maintain the normal functions of each individual, and the consequent up-keep of the birth-rate, has reached what Woodruff calls the "saturation point." Beyond this the land is over-saturated in relation to population, an additional increase causing food shortage. An under-saturated land is one of potential possibilities. The whole question turns upon the intelligent exploitation of the soil; a people of low agricultural instincts may occupy a land that would yield a hundredfold to another people of high agricultural instincts, and yet for want of tillage this first people may represent a mere handful at starvation point, and the land in relation to this scanty population be over-saturated. Just such a condition prevailed among the aborigines of America; they were mainly a scattered, non-agricultural hunting folk, living a hand-to-mouth existence in a land that later was capable of supporting many millions of intelligent, agricultural Europeans.

The history of nations is largely a record of warfare, and this warfare, is, in ultimate analysis, an effort to acquire more food. Supersaturation brings about migration, and migrating hordes must fight their

way into new territory. Organization develops a superior fighting body of population, and this has passed, in its higher phase, from mere battle and bloodshed to the problem of trade expansion and commercial supremacy. It is still one and the same in its basic principle. Population is subject to the same laws of universal energy under which all material things operate. Nomadic peoples are kinetic, continually on the move with their flocks and herds, continually at war, and always expending energy. Agriculturists, on the other hand, are static, building up energy in the form of plant food which is potential in nature. History is one long drama of events in which the aggressive, kinetic nomad is forever trying to absorb the potential energy of the agriculturist, swooping down out of the desert and the grasslands on the rich agricultural communities of river valleys to become the ruling power for a time, thriving at the expense of the conquered agricultural laborer, energizing the mass of population, an effective motive power of organization, absorbing the food potential, creating wealth and ultimately being absorbed itself in the great static body of the people. Mesopotamian, Egyptian, Persian, Grecian, Roman, Barbarian, Celt, Saxon, Norman Slav, Hun, Turk and Manchu—each alike has battened and waxed great on the potential of some agricultural people. Every war of conquest, every rise of empire and civilization, is but the expression of this conversion of food potential into active, kinetic processes of organization.

Various phases of animal life assert themselves as by-products in the general trend of organization. Two of these—symbiosis and parasitism—are worthy of note inasmuch as they appear not only in the lower world of animal life, but likewise, in the social organism, as a result of the same fundamental conditions. The domestic animals and man is as much a case of symbiosis (the living together for mutual advantage) as is that of the ants and aphides, or the polyp and the hermit crab, for both derive an advantage from the care by one and the labor and resources of the other. Parasitism appears in social organization in the form of pauperism and in the position of woman under certain phases of culture.

Woman represents a potentially nutritive principle, one that is very widespread throughout nature and life. The male has not only continually liberated this potential energy in the normal function of race increase, but has also utilized the woman's powers in agricultural and domestic conservation. Her individual energy was absorbed in the general race energy, which the male exploited by virtue of his greater kinetic activity. The modern phase of aggressiveness in woman is part of a general development of individualism throughout population at large, irrespective of sex, and is not to be regarded as a special and peculiar manifestation of the modern female. Under certain aspects it partakes of the nature of a mob movement, a rising tide of emotional disturbance

from suggestion, for, as a psychologist once observed, "man is a most suggestible animal." It is undoubtedly a reactive expression along the same lines that have led to the republican forms of government, the limitation of monarchial power, and the idea of the freedom of the individual in general.

The mouthings about sexual distinctions in brain and in mental ability as indicating inferiority or superiority have no foundation in biology. Nor is it ever a question of equality from a biological standpoint. It is a question of complementary development, resting absolutely on a natural law, that of the conservation of energy. Havelock Ellis in his interesting book, "Man and Woman," remarks upon the greater "affectability" of woman as compared with the male; a readier response to emotional stimuli as a result of her more mobile vaso-motor nervous system and the greater rôle which the abdominal organs play in her life. This physiological fact must be recognized in considering any question relating to the expansion of woman's sphere. The same writer also observes that woman is nearer the child in her general development, but "is not undeveloped man," that "the child represents a higher degree of evolution than the adult," and that "the progress of the race has been a progress in youthfulness—in some respects it has been a progress in feminization." In the process of individual expansion woman is bound to free herself from worn-out patriarchal traditions. One thing, however, she will never escape—the fundamental, potential nature of her organization, for by her bodily powers the race exists, and her mind takes on the same qualities; not the kinetic, inventive faculties of the restless male, but the steadfast, race-fostering qualities of the mother.

Each individual man, conscious of his impulses and activities, comes to regard his work and the work of his fellows as of purely human origin. The cities; the means of transportation and communication; the activities of trade; the affairs of state; the development of resources; the pursuit of wealth and pleasure; the things of the mind —each and all seemingly belong to a world far removed from that of the animal. A more profound insight into this field of human endeavor reveals its deep rootage in the organic world. What a man does and thinks is not so much a product of his conscious being as it is of his relation to the whole mass of population. Each individual is but a unit in what H. G. Wells has so aptly called the "soak of population." And population is drifting like the plankton out of which it has evolved, organizing through combinations of its units into manifold phases of activity and varieties of structural means, toward some end, undoubtedly, but nevertheless drifting, not moving definitely from any collective sense of its own, with an end in view, but drifting in the vast ocean of the Infinite.

THE MISSISSIPPI GULF THREE MILLION YEARS AGO

By Professor EDWARD W. BERRY
THE JOHNS HOPKINS UNIVERSITY

THE traveler from Chicago to New Orleans, if on the fastest train, leaves Cairo, Illinois, at 3.40 A.M. and covers the 566 miles to the Crescent City in 17¾ hours. Little does he realize that all this while the train is speeding along an old bed of the sea.

At the dawn of that stage of the earth's history, which geologists call the Cenozoic or era of modern life, the waves of the Gulf of Mexico rolled northward as far as southern Illinois. This area of submergence, which was covered many times by ocean waters during geologic time, has been called the Mississippi embayment or Gulf. It was no narrow arm of the sea like the Gulf of California, but a broad expanse of water with its shores receding rapidly from one another as they passed to the southward. At Jackson, Mississippi, the traveler is over one hundred miles from the old eastern shore and the western shore is more than 350 miles to the westward.

The old eastern shore bends to the eastward in Kemper County, Mississippi, and all the region to the southward was under water. The sites of Memphis, Meridian, Vicksburg and Shreveport were all submerged, although the water was never very deep, as is shown by the forms of marine life preserved as fossils in the sediments. Probably a ship, if there had been ships in those ancient days, could have anchored anywhere in the Gulf, since it was nowhere over 50 fathoms deep and throughout most of its area it was much shallower.

Perhaps a long familiarity has bred an indifference to the wonders of the past hidden in the sands and clays of the eroded hill country, but more likely the story that they have to tell is entirely unsuspected. Geologists have studied these sands and clays, collecting the fossil shells and petrified woods from the sands and the impressions of leaves and other parts of plants entombed in the clays. They have named and described many of these ancient forms of life, both the dwellers in the sea and on the land, and have mapped the landward margin of the deposits that give us a picture of the position of the old shore line.

The Cenozoic era is divided into distinct periods the oldest of which, the Eocene period, or dawn of recent life, is so named since its rocks contain forms foreshadowing our existing plants and animals. It is the geography and other physical conditions of the lower Eocene in this region to which I wish to direct attention, paying especial heed to the character of the vegetation that clothed the lower Eocene shores. The

remains of this old flora are found entombed in the clays of the old lagoons and bayous, preserved as delicate impressions of leaves, flowers and fruits hermetically sealed as they sank and were covered by the fine-grained muds that formed the clays. Their remains in regions that were swamps, or where the lagoons were shut off from rivers with their seasonal loads of sediment, on the one hand, and were likewise separated from the sea by barrier beaches, on the other, rotted and accumulated to form the beds of lignite so common throughout the Gulf states and now mined in many places, particularly in Arkansas and Texas.

The area of this lower Eocene Mississippi Gulf is shown in the accompanying sketch map (Fig. 1).

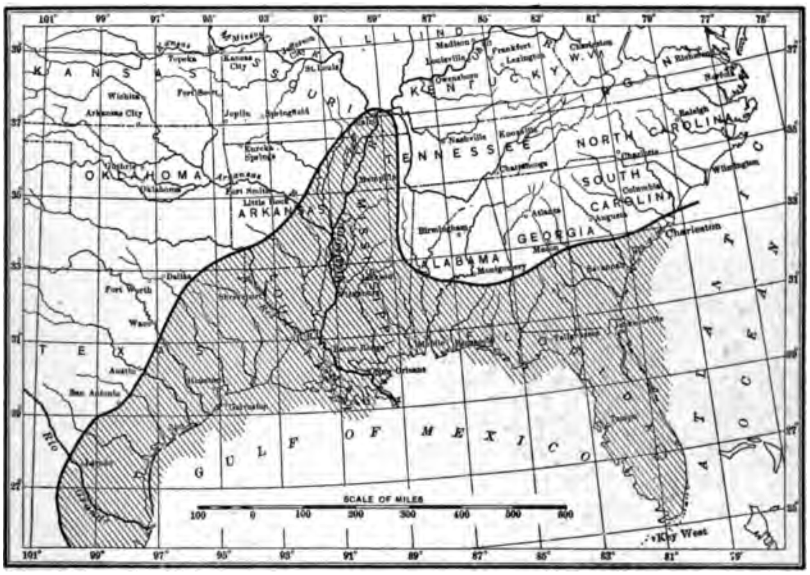


FIG. 1. THE MISSISSIPPI GULF OF LOWER EOCENE TIME.

The title of this article places the antiquity of the Mississippi Gulf shown in Fig. 1 as about three million years. This is, of course, not as fixed as a date in human history, but may be compared with the approximations to dates in human history antedating written records. Geologists have used a great many methods in their efforts to compute the lapse of geologic time, the most readily understandable being that based on the thickness of the sediments and their rate of accumulation. If sediments only accumulated at given rates throughout all time and were never washed away, it would be possible to translate thicknesses into years with considerable accuracy. With the uncertainties surrounding the problem, the most careful calculations are only approximations—useful enough in a way and serving to give a fairly accurate ratio when one geologic period is compared with another. Millions of years

mean but little to mortals, the most far sighted of whom rarely think in longer terms than decades or generations, and one can obtain a more impressive concept of the remoteness of this period from the absence at that time of the immediate ancestors of any of our higher animals. If there were ancestral horses thus early, they were small as foxes and had five toes on all four feet. If there were ancestral elephants, they had a full complement of teeth, and their incisor teeth had not commenced to lengthen into tusks or their upper lip elongate into a trunk. The huge uncouth reptilia of the age of reptiles still lingered in the land. The forests were filled with extinct trees and were more like those of Brazil in their physiognomy than like any now growing in our

FIG. 2. A RECENT VIEW TO ILLUSTRATE THE PROBABLE APPEARANCE OF A LOWER EOCENE BAYOU ON THE NORTHERN MISSISSIPPI.

southern states. The loftiest modern mountains—the Himalayas—like the Alps, had not yet lifted their heads. Man was not even a promise and we may be sure that whatever the exact number of years, thousands of years multiplied into millions. And yet it is possible to piece together a very satisfactory picture of the life and its environment from a combination of the study of the character of the sediments and of the forms of life they contain.

First of all, the shores were low and the streams were slow and meandering, expanding in their lower courses into broad forested swamps and winding bayous inhabited by crocodiles. Such a bayou is indicated by the deposits near Oxford, Mississippi, where river clams

are found in the clays and the drifted vegetation in certain layers is much broken. In other layers one finds a profusion of the leaves of a fan palm, sometimes three feet across and not unlike the modern palmetto that must have been exceedingly abundant in the delta region. Elsewhere one can trace the outline of these old bayous by the lignitic black clays, and sometimes, where sand and silt failed to penetrate a swampy estuary, the vegetable material has afforded coal-mining developments, as at Hoyt, Texas, where mining operations have followed the narrow winding coal bed for a distance of about three miles. The probable appearance of such a bayou is indicated in Fig. 2.

Beyond the strand there stretched lagoons of quiet water often very wide and at times completely shut off from the sea by barrier beaches covered with strand plants which formed a beach jungle, such as one meets with in the present-day tropics. The extent of many of these landlocked lagoons is marked to-day by the lenticular beds of clay imbedded in the sands and narrowly elliptical in form, their long axes parallel with the old shore line. The climate of the lower Eocene was mild, for we find traces of the breadfriut tree in Arkansas and Louisiana; a host of fig trees, camphor trees and rain trees in Tennessee, and palms everywhere. The character and quantity of the vegetation shows also that the rainfall was abundant.

A total of over 350 different species of plants have been described from these deposits, and some of the plants recognized are of exceptional interest. There are great quantities of camphor trees and laurels, the former so abundant to-day in the Orient and the latter so common in northern South America. The fig, or banyan, family also furnishes a large number of species, including three or four different members of the breadfruit tribe. Another very large alliance was the Leguminosæ which, to mention only such modern forms as have fossil relatives in the lower Eocene, include our acacias, mimosas, locusts, rosewoods, Judas trees, rain trees, sennas and horsebeans. Other especially well represented families are the soapberry (Sapindaceæ), myrtle (Myrtaceæ), sapota (Sapotaceæ) and combretum (Combretaceæ).

Among the more interesting finds was the remains of the nuts of a Nipa palm. The modern Nipa comprises but a single gregarious species inhabiting the tidal waters of the Indian ocean and ranging from the Sunderbunds of the Ganges through Malaysia to the Philippines. It is a stemless form with clusters of gigantic pinnate leaves rising directly from the mud of the tidal flats. The nuts are borne in clusters and resemble small, ribbed coconuts. The estuaries of the Ganges and other oriental streams, as well as ocean currents off the southeastern coast of Asia, often carry large numbers of these nuts in their drift, exactly as did the currents along the shore of the lower Eocene Mississippi embayment and in the Eocene estuaries of southern England, the Franco-

Belgian basin and southern Russia. The habit and environment of the modern Nipa are shown in Fig. 3. The mild climate of the Eocene was world wide in its extent and similar Nipa nuts have been found in Europe at that time as far north as southern England. They are exceedingly common in the estuary clay of the island of Sheppey in the Thames basin. None, however, have previously been found in the whole western hemisphere.

FIG. 3. A TIDAL NIPA PALM SWAMP IN THE PHILIPPINES TO ILLUSTRATE LOWER EOCENE CONDITIONS IN MISSISSIPPI. (Courtesy of Philippine Bureau of Science.)

Another exceedingly interesting find was the winged fruits as well as the leaves of several species of *Engelhardtia*. *Engelhardtia* is a genus of trees belonging to the walnut family, but, unlike the walnuts and hickories, the seed part of the fruit has remained small, thus facilitating the production of a large number of seeds. The bracts, which are inconspicuous in the walnut, have become enormously enlarged in the *Engelhardtias*, so that each seed has three large wings to aid its dispersal. In our lower Eocene the oldest known representative of these trees shows the initial type of the winged fruits, so much more primitive than *Engelhardtia* that it is referred to a new genus named *Paraengelhardtia*. Associated with *Paraengelhardtia* are true Engelhardtias, also the oldest known, and both are new to the western hemisphere. The modern forms number about a dozen, and all but one of these are confined to the Orient, where they range from the northwestern Himalayas through farther India and Burma to Java and the Philippines. One form, probably a descendant and relic of this abundant Eocene display in the Mississippi embayment region, is still found

in the mountains of Cost Rica, and a considerable number are found in the upper Eocene and later Tertiary of central and southern Europe.

Sometimes such delicate objects as flowers are preserved in the clays and two of these are shown in Fig. 4. The larger with the long-

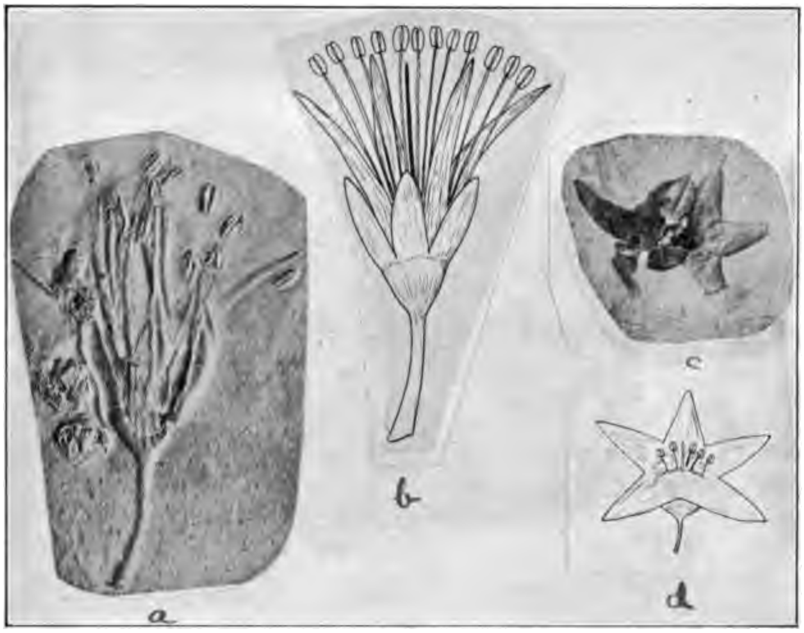


FIG. 4. FOSSIL FLOWERS FROM THE LOWER EOCENE OF THE GULF COAST. *a*, Combretanthites as photographed; *b*, Restoration of the same; *c*, Solanites as photographed; *d*, Restoration of the same.

exserted slender stamens and large anthers is named *Combretanthites* or *Combretum* flower, and belongs to the family Combretaceæ, or Terminaliaceæ, as it is sometimes called. The family comprises about 16 genera and 285 existing species of shrubs, trees and tropical vines found on all the continents except Europe and Antarctica. Many of the forms are strand types and several are characteristic of the tidal mangrove swamps. Nine species belonging to this family and referred to the genera *Combretum, Terminalia, Conocarpus,* and *Laguncularia* are found in the lower Eocene of the Mississippi embayment. The last two are mangrove plants, occurring in swamps on both sandy and muddy bottoms in brackish tidal waters. Both are distributed by ocean currents from tropical America to the west coast of Africa. *Laguncularia,* the buttonwood or white mangrove, has never been found fossil before, although we find both leaves and fruit in the clays of Mississippi and Tennessee. Only one other fossil occurrence of *Conocarpus* is known and that is European and much later in age.

The second flower figured is called *Solanites,* since it belongs to the night-shade family or Solanaceæ, the family that contains our modern potatoes, tomatoes, tobacco, etc. The family is a large one in existing floras and mostly tropical in its distribution but its geologic history is almost entirely unknown. One other *Solanites* flower has been described from somewhat younger deposits in southern France.

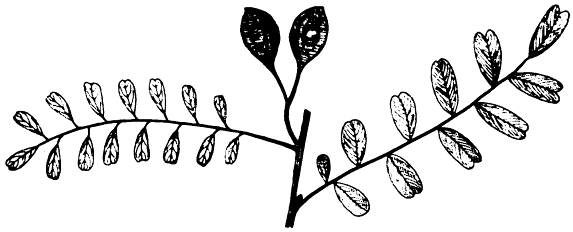


FIG. 5. RESTORATION OF LOWER EOCENE DALBERGIANS FROM TENNESSEE. A composite of Dalbergia monospermoides (fruit) Dalbergia wilcoxiana (leaflets at left) Dalbergia eocenica (leaflets at right).

A genus of trees which were very abundant in the lower Eocene of both this country and Europe belongs to the oak family or Fagaceæ. It is entirely extinct and is called *Dryophyllum.* Its leaves are much like those of the modern chestnuts and chestnut oaks, and they are very abundant throughout the lower Eocene of the Mississippi embayment, several species being represented. *Dryophyllum* is considered to represent the ancestral stock from which the modern oaks and chestnuts descended.

Among the Leguminosæ, which I have already mentioned as being very abundant, are several which deserve some special comment. Among these are seven species of the genus *Sophora,* evidently strand types, and one of these, which was exceedingly abundant in west Tennessee, is scarcely to be distinguished from the existing cosmopolitan strand plant of the tropics, *Sophora tomentosa.* Another interesting find belonging to this family was the trifoliate leaves of two species of *Canavalia,* the first ever found fossil. One of these is almost identical with the existing vine *Canavalia obtusifolia,* a widely distributed tropical strand plant, found in abundance on the sandy beaches of the West Indies, prostrate on the sand or clambering over the beach jungle. A third genus of this family, *Dalbergia,* to which the rosewood of commerce belongs, is represented by four species. The leaves of two of these combined with the characteristic one-seeded pods as they occur in the clays of western Tennessee are shown in the restoration, Fig. 5. Another leguminous genus exceedingly abundant in our lower Eocene, where it is represented by eight species of leaves and pods, is the extinct genus *Gleditsiophyllum.* A restoration of the commonest form which greatly resembled our modern honey locust is shown in Fig. 6.

One other genus of legume deserves special mention, since it has an abundance of fossil leaves and pods. This is the genus *Cassia,* to which

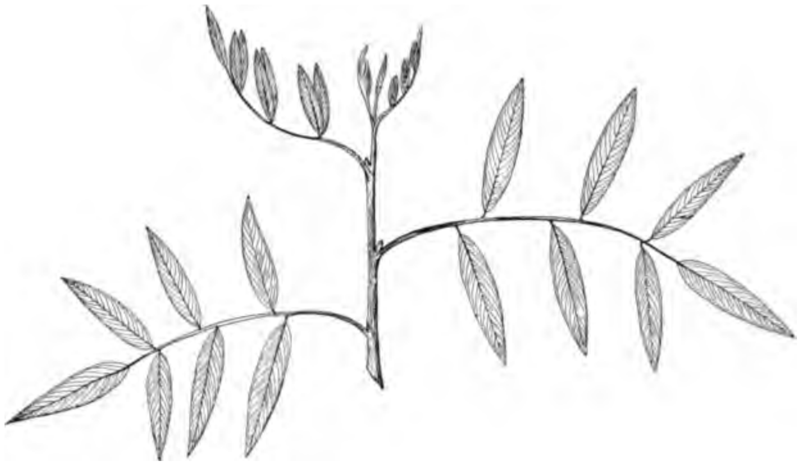


FIG. 6. RESTORATION OF GLEDITSIOPHYLLUM EOCENICUM BERRY. From the Lower Eocene of Tennessee.

the senna as well as our common herbaceous sensitive plants belong. The modern cassias range from herbs to trees and are very abundant

FIG. 7. RESTORATION OF A FOSSIL CASSIA ABUNDANT IN THE LOWER EOCENE OF MISSISSIPPI AND TENNESSEE.

and varied, between three and four hundred species having been described from the warmer temperate and tropical climes of all the con-

tinents. They are especially common in tropical America and have a long geological history extending from the Upper Cretaceous age to the present. Twelve different species have been discovered in the lower Eocene of the Mississippi embayment and a restoration of one of these that had both its pods and leaves preserved is shown in Fig. 7.

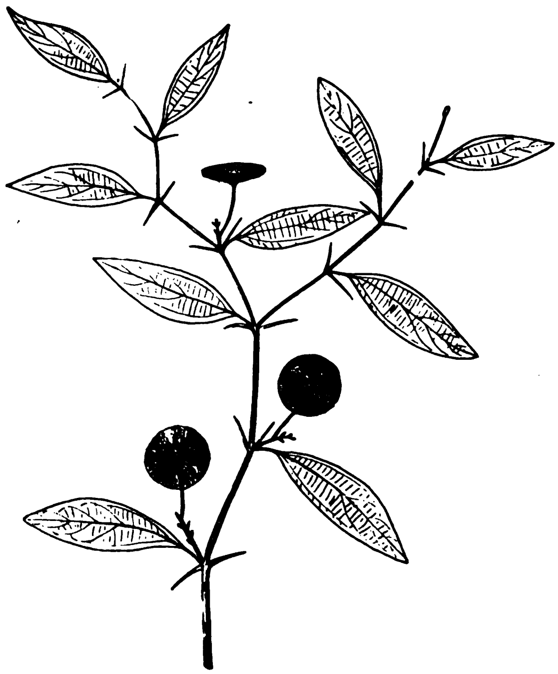


FIG. 8. RESTORATION OF PALIURUS based on Fruits and Leaves found in the Lower Eocene of Mississippi and Tennessee.

A family of plants no longer found in temperate North America is the family Sterculiaceæ, which also has a long and interesting geological history extending from the Upper Cretaceous to the present. Among the fossil leaves of the lower Eocene are an abundance of large three, four or five lobed leaves, eight to ten inches across, of a magnificent *Sterculia,* scarcely distinguishable from the modern Asiatic *Sterculia platanifolia,* which is often cultivated in the parks of our southern states. There are also large five-celled capsules of two species belonging to this same family. These I have called *Sterculiocarpus,* since they are not exactly like those of any of the existing genera of this family.

I will mention but one other of the 63 families that are represented in this remarkable lower Eocene flora.

The buckthorn family or Rhamnaceæ has furnished no less than fourteen fossil species in this area, representing the genera *Rhamnus,*

Rhamnites, Reynosia, Zizyphus and *Paliurus*—the first being the most varied with six species. The genus *Paliurus* is of especial interest, not only because it is represented by the very characteristic fruits as well as by the leaves, but because it has such an extended geologic history and was formerly cosmopolitan. In the later Tertiary it dwindled, and in the existing flora it has only two species which are found from southern Europe through southern Asia to China and Japan. Fossil forms are found as early as the Upper Cretaceous, at which time at least a dozen species, all North American, have been described, seemingly indicating an American origin for the genus. The leaves are not common in the lower Eocene of the embayment, but the characteristic peltate fruits are not rare, and the two combined have furnished the data for the restoration shown in Fig. 8.

One might cover many pages with comments concerning fossil malvaceas, cedrellas, laurels, bombaceas, apocyneas, malpigias and all the other interesting fossil plants that give us a glimpse of the vegetation of this far-distant chapter of earth history. This flora, the first of its kind that contained types that invaded our country from the south, has been rather fully described recently and the reader who wishes to know more about it is referred to the published account.[1]

It must not be supposed that the strand line which seems to be such a striking and constant geographic feature remained stationary in the position shown in Fig. 1. The strand advanced and receded many times, as it has always done in all parts of the world. Geologic events, however, move with such extreme slowness when measured by human standards that such changes are not perceptible to contemporary life. At the beginning of the Eocene the coast line of the Mississippi Gulf was far to the southward, almost where it is to-day, and the advance of the sea northward to the mouth of the Ohio was a gradual process requiring some thousands of years for its accomplishment and measured by an observable evolution in the life forms found in its sediments. This constitutes one of the practical applications of paleontology, since, given a collection of fossil plants or shells, the paleontologist can tell the geologist whether a particular stratum is young or old and into just what niche of geologic time to fit his coal bed or artesian water horizon.

[1] Professional Paper 91, U. S. Geol. Survey.

THE SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH.

THE PROGRESS OF SCIENCE

THE SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH

The new wharf and library-museum building at the Scripps Institution for Biological Research of the University of California, at La Jolla, made possible by the gift of the $100,000 by Miss Ellen B. Scripps in 1914, were dedicated last summer. President Benjamin Ide Wheeler, of the University of California, presided, and short addresses were made by Ex-chancellor David Starr Jordan, of the Leland Stanford Jr. University; Director D. T. MacDougal, of the Botanical Research Department of the Carnegie Institution of Washington; Professor G. H. Parker, of Harvard University, and Dr. Wm. E. Ritter, the scientific director of the institution.

The wharf, one thousand feet long and twenty feet wide, is of reinforced concrete except the deck. At its sea end are the pump for the salt water circulatory system with the electric motor for running it, a tide gauge, a self-registering thermometer for keeping the temperature of the sea water, a current meter, a small naturalists' house, two sets of davits for hoisting small boats on to the wharf, two companionways, one on each side, which can be lowered and raised by winches provided for the purpose, and various contrivances to facilitate the work of handling boats and making collections and observations from the wharf.

This addition to the institution's "plant" very greatly increases the facilities for carrying out the marine part of the research program. Besides securing to the research and exhibition aquaria an ample supply of oceanic water (the site of the institution is on an open coast), it makes a large number of animal and plant species of the oceanic plankton available for statistical and experimental investigation without the expense and inconvenience of boat work.

The usefulness of the wharf for reaching out to the open ocean is largely enhanced by a small high-power motor boat, a gift of Mr. E. W. Scripps. As this craft can be lowered from its davits in a few minutes and as it easily makes twenty miles an hour, the operating radius from the laboratory for a wide scope of planktonic and hydrographic conditions with two men for doing the field work, and during a period of several hours, is twenty to thirty miles With its present equipment the marine side of the institution may be looked upon as a sort of perpetual deep-sea plankton expedition, working intensively rather than extensively.

It is greatly hoped by the management of the institution that the unique facilities in this respect afforded by the institution will serve to attract more attention from American naturalists to this great domain of nature than it has received in later years.

The library-museum building, constructed of concrete and hollow tile, is two stories high, each story having a height and window arrangement for gallery as well as main floor stacks. By this plan the potential capacity of the building is somewhat more than 50,000 volumes. But for the present and for some years to come only one of the stories—the upper—is needed for the library. The stack room now in use has a capacity of 25,000 volumes at least. This provides for the growth of the library for the next five, possibly the next ten, years. The librarian's room, the catalogue room, and a large reading room used also as

an assembly hall, are likewise on the second floor.

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methods of making newsprint paper, and of the production of paper from woods hitherto unused for that purpose, which have been conducted, kraft paper, which compares favorably with the best on the market, has been produced experimentally at the Forest Products Laboratory from longleaf-pine mill-waste. This kraft paper is brown in color and is very much stronger than ordinary papers. It is used for a variety of purposes, and, cut into strips, is spun or twisted into thread which is then woven into onion and coffee bags, matting, suitcases and wall covering, similar to burlap, and furniture closely resembling that made from reeds, as well as other articles of common use.

Within the past year the Forest Products Laboratory has, by cooperating with manufacturers, succeeded in getting a dye made from mill-waste of osage orange put on the market as a substitute for fustic, which we import from Jamaica and Tehuantepec.

These are only a few examples of the various lines of work carried on at the Forest Products Laboratory. Other activities, ranging all the way from the study of decay in wood to that of the resistance of wood to fire, are in progress, and new discoveries are constantly being made. Incidentally, the Forest Products Laboratory, at Madison, Wis., was the first of its kind in the world and is probably still the best equipped. With the possible exception of Germany, no other country has done as much as the United States systematically to investigate the possibilities of its forest resources.

SCIENTIFIC ITEMS

We regret to record the death of Sir Edward Burnett Tylor, professor emeritus of anthropology in the University of Oxford; J. B. A. Chauveau, member of the section of agriculture of the Paris Academy of Sciences and of Dr. E. Gaupp, professor of anatomy in the University of Breslau.

Dr. Julius Stieglitz, professor of chemistry in the University of Chicago, has been elected president of the American Chemical Society. Dr. Stieglitz has also been elected president of the Society of Sigma Xi. The gold medal of the Royal Astronomical Society has been awarded to Mr. W. S. Adams, of the Mount Wilson Solar Observatory, for his investigations in stellar spectroscopy.

The Elisha Kent Kane medal of the Geographical Society of Philadelphia has been conferred on Dr. William Curtis Farabee for his explorations in the Amazon Valley. The alumni of Columbia University have given a dinner in recognition of the university's contributions to science and engineering. The guest of honor was Professor M. I. Pupin, who completes his twenty-fifth year of service to the university.

At the annual meeting of the trustees of the Rockefeller Foundation Dr. George E. Vincent, president of the University of Minnesota, was elected president of the foundation to succeed Mr. John D. Rockefeller, Jr., who was appointed chairman of the board of trustees. Messrs. Charles E. Hughes, Julius Rosenwald, of Chicago, and Dr. Wallace Buttrick, chairman of the General Education Board, were also elected trustees, and Mr. Edwin Rogers Embree, assistant secretary of Yale University, was elected secretary to succeed Mr. Jerome D. Greene. Dr. Marion L. Burton, president of Smith College, has been elected president of the University of Minnesota to succeed Dr. Vincent.

Vol. 4, No. 4 APRIL, 1917

THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

CONTENTS

THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: SUB-STATION 84

SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION,

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To this end a tract of about one hundred and sixty acres was set aside, and extensive plantings were made; but unfortunately whoever was responsible for the original planting evidently did not entirely appreciate the needs of many of the species that were selected, and consequently very many of these have not survived the vicissitudes to which the arboretum has been subjected since it was first laid out. For instance, a large number of trees from the Atlantic States were planted, without realizing that they are not at all adapted to withstand the long dry summer of California, and consequently the greater part of these have disappeared and the few that have survived have made very little growth.

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The topography is varied and picturesque, including parts of the level valley floor, but extending well into the foot hills of the Santa Cruz Mountains, which are 2,000 to 3,000 feet in height, and shelter the western side of the valley. The highest points on the Stanford estate are about 700 feet above San Francisco Bay. Much of the higher land is well wooded, and there may be found most of the trees and shrubs native to the valley—over sixty species have already been noted.

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The most remarkable are two redwoods (Fig. 3) planted by President and Mrs. Hayes in 1880. The taller of the two is now 110 feet in height with a girth of 8 feet, 8 inches, at five feet elevation. The other, while not so tall, has a girth of exactly ten feet.

Most of the other characteristic genera of native Conifers: *Pinus, Abies, Thuja, Libocedrus, Cupressus, Torreya, Pseudotsuga*, are well represented by numerous examples. The Monterey pine (*Pinus radiata*) and Monterey cypress (*Cupressus macrocarpa*) are by far the most frequently planted.

The Eastern species of Conifers are not quite at home in California, and there is but a meager representation of these. The southern cypress (*Taxodium*) and the white pine, however, do fairly well.

Many exotic Conifers grow luxuriantly, and there is already an excellent collection. The oriental cedars (*Cedrus*) are well represented by numerous thrifty trees of all three species, *i. e.*, the cedar of Lebanon, the deodar, the Atlas cedar, all of which are very much at home. Several species of *Araucaria* represent this interesting section of Coniferæ, and various species of pines, firs, spruces, arbor vitæ, yews, Cryptomeria, etc., from different parts of the Old World, make the collection already established decidedly worth seeing, and it is expected that the number of these exotic Conifers will soon be materially increased.

Eucalypti of several species were freely planted when the arboretum was originally laid out, partly as a shelter for more delicate trees. These are now large trees and it will be necessary, from time to time, to remove a good many of them to make way for other trees. Some of these great *Eucalyptus* trees are magnificent specimens of their kind, and will be permanently retained, as they form one of the most striking features of the arboretum. The majority are the common blue gum (*E. globulus*), but there are many specimens of several other species, and in time the number of species of *Eucalyptus* will be much increased, as this characteristic Australian genus finds a most congenial home in California.

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FIG. 2. CALIFORNIAN LIVE OAK, *Quercus agrifolia.*

cipitation (mostly from October to May) is seldom more than 20 inches, and usually less. In the foothill region, however, it is noticeably greater.

The lowest temperatures usually occur in December and January, when light frosts are quite common, but usually not sufficient to damage any but the tenderest plants. The usual winter maxima are 50 to 60 degrees, and the winter is a period of active growth.

The climate much resembles that of warmer parts of the Mediterranean region, and the same plants are met with. Olives, figs, vines and all of the "deciduous" fruits thrive, and the citrus fruits—oranges, lemons and grapefruit, are easily grown, but are seldom planted on a commercial scale. Palms of several species, including the native fan-palm (*Washingtonia*), are very commonly planted and the gardens are adorned with a great variety of evergreen trees and shrubs from various parts of the world.

The proximity of the ocean tempers remarkably the summer climate of the whole coast region, which offers a strong contrast to the intense heat and dryness of the central valleys and the southeastern part of the state. This temperate summer makes it possible to grow to great perfection most of the plants of northern Europe, which do not thrive in the hotter and drier parts of California.

It is evident then that climatically the conditions at Stanford are extremely favorable for the growth of a very large number of species;

and with irrigation, and slight winter protection, the number may be greatly increased.

The arboretum at present comprises about 200 acres, but in addition to this there are extensive plantations about the university buildings and the Stanford residence. These latter plantations include many unusually fine specimens of both native and exotic trees and shrubs.

As might be expected in California, so famous for its native coniferous trees, the Conifers constitute a conspicuous feature of the arbo-

FIG. 3. REDWOODS PLANTED IN 1880. The taller tree is 110 feet in height.

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FIG. 5. IN THE "ARIZONA GARDEN."

and shrubs are unknown in the parks and gardens of the Atlantic States. A few, such as the European elms, ashes, horse-chestnuts, maples and sycamores are old friends, and a small number of species from the Atlantic States will be recognized, but for the most part, both trees and shrubs are strangers to the Eastern horticulturist. The Australian eucalypts, acacias, grevilleas, pittosporums and sterculias; the new Zealand veronicas, cordylines and coprosma; the Mediterranean myrtle, laurels, cistus, oleanders, brooms, etc., the pepper tree and other

FIG. 6. MAIDENHAIR TREE, *Ginkgo biloba.*

unfamiliar South American contributions, with still others from South Africa and Mexico, give the arboretum a very different aspect from that of any similar collection in the Atlantic States.

The majority of these are evergreen and many are now trees of great size, which afford a splendid setting for future plantings. It will be necessary from time to time, as we have said, to remove some of the older trees to make room for new plantings, but this will be done as carefully as possible.

FIG. 7. PALM AVENUE.

Among the unusual features of the present arboretum is the "Arizona Garden," which contains very fine specimens of various xerophytic plants, especially cacti in considerable variety. Here may be seen fruiting specimens of the giant *Cereus* of Arizona, as well as huge plants of the common prickly pear, and other species of *Opuntia*. With these are associated various species of yucca, century plants, aloes, mesembryanthemum, and other characteristic plants of warm and arid countries.

The plans for the future development will have to be made somewhat gradually. As far as possible the species of the same family will be grouped together, but as the arboretum is part of the ornamental grounds of the university, it will be necessary to bear this in mind, and, so far as possible, to combine the scientific arrangement with the most advantageous landscape effects. Moreover, the cultivational needs of the different species must be taken into account. In a climate where for six months no rain may fall, the question of irrigation is an all-important one, and the water needs of the plants must largely control their position in the arboretum.

A special effort will be made to have as complete a collection as possible of the woody plants of California. The flora of the state comprises a very large number of extremely beautiful and interesting trees and shrubs, a fair number of which are already represented, but a much larger number of which are still to be planted. The many exotic species which thrive in California will, however, receive due attention.

The climate of most parts of California is not naturally adapted to the plants of Atlantic North America, as these need for their normal growth the hot humid summer of the East. The same conditions are necessary for most of the Japanese and Chinese species. If these are planted where they can be freely irrigated during the summer they grow luxuriantly, but few of them can endure the long dry summer without irrigation. When such trees as the American elm, white ash, or *Magnolia grandiflora* are planted in a lawn, which has to be frequently watered, they grow vigorously and soon form good-sized trees.

There are a great many species from the drier warm temperate regions of the world, which are very much at home in California, and which once established require very little attention. Thus many of the Australian eucalypts and acacias grow with amazing rapidity, and a long list of Australasian genera are abundantly represented in our Californian gardens and parks. The Mediterranean region furnishes a large assortment—laurels, evergreen oaks, carobs, heaths, cypresses, etc.—all of which do quite as well in California as on the Riviera. South Africa has its quota of beautiful shrubs and herbaceous plants, and the warm temperate countries of South America—Peru, Chile, Brazil and Argentina—have contributed a host of showy species, pepper trees, fuchsias, heliotrope, passion flowers, bignonias, bougainvillea, etc.

As in all of the warmer parts of California, palms are extensively grown, and although their growth is decidedly slower at Stanford than in Southern California, they nevertheless are very commonly planted,

FIG. 8. GROUP OF PALMS IN THE QUADRANGLE.

and give a marked tropical touch to the landscape. On the university grounds at present there are grown some eight or ten species, and the palm avenue leading from the entrance of the estate and traversing the arboretum, a distance of nearly a mile, will attract the attention of the most casual visitor. There are some fine groups of palms, also, in the inner quadrangle of the university (Fig. 8). The arborescent yuccas, dracænas and cordylines are also freely planted in the university grounds.

It is therefore evident that there is a very wide field from which to select, comprising, probably, several thousand species which can be grown successfully in the arboretum as it is now being developed. Just how many, time will tell.

The writer is indebted to Professor L. L. Burlingame, of the department of botany of Stanford University, for the photographs used here as illustrations.

LIFE INSURANCE PROBLEMS[1]

THRIFT FROM THE LIFE INSURANCE VIEWPOINT

By ELMER E. RITTENHOUSE
NEW YORK CITY

LIFE insurance has been diligently working in the thrift vineyard for many years. For more than two generations it has been carrying its message of providence, of rational economy, of preparedness against adversity, into the homes of our people. Its greatest foe has been extravagance and the spendthrift tendency of the times. But in spite of these enemies, it has induced a vast body of Americans to conserve at least some of the fruits of their thrift. Its success has been far beyond the wildest dreams of its pioneers. It has not only been successful in promoting thrift, but through the investments of the immense accumulation of savings of its patrons, it is helping to keep the wheels of progress in motion by helping to develop commerce and the resources of our country. It has become a mighty constructive factor in our national life. It has observed the (per capita) wealth of our people increase over 500 per cent. in sixty years, and bring with it a train of new and costly living conditions.

In these days of prosperity, prodigality and waste, almost any man can earn money, but it takes a wise man to induce him to save much of it. We have an excessive number of people who are living up their entire earnings; we have many living beyond their means and mortgaging their future earning power in the pursuit of pleasure and luxury. Their motto is: "Be a sport, spend it to-day; to-morrow may not come." But to-morrow does come. And then, minus earning power, their pride and independence is suddenly changed to humiliation, and dependence upon others for their daily bread.

Scattered throughout the homes of our land, from miserable shacks to humble and pretentious cottages and dwellings, and even in mansions, are thousands of dependent people who have passed out of their earning period financially helpless. But still their fate holds no lesson for many people. With all our wealth and pride and independence, we still have a large number of men who are willing to leave their families

[1] Papers presented before the Section of Social and Economic Science of the American Association for the Advancement of Science, December 28 and 29, 1916, and communicated to The Scientific Monthly by the secretary of the section, Seymour A. Loomis.

to eat the bread of charity from the reluctant hands of relatives or of the state, rather than to practise a little economy and to provide them at least with life insurance protection.

We rejoice to know that our prosperity is unprecedented, that we have more homes, more schools, more savings bank deposits, more food, more clothes and more time for pleasure than ever before, but we must not forget that the worthy poor, as well as the improvident and wasteful poor, are still with us. It is a glorious thing to know that so far as necessities and comforts are concerned our people have a higher standard of living than those of other countries, but this can not serve as an excuse for them to abandon all prudence in expenditures and to wallow in costly luxuries and pleasures, oblivious of the lean, non-productive years that are to come.

There are still several millions of Americans needing life insurance, and this number is augmented every year by the young who reach the insurable age. To these people life insurance is appealing with steadily increasing success. But it does not succeed by trying to frighten people into the fold. It is useless to point to the fate of Persia, Athens, Rome or Bourbon France. It points to a lesson nearer home. It appeals to the man who wants to be independent instead of dependent in his old age. It appeals to his natural desire to protect "his own" against the chilly blasts of adversity when he can no longer protect them. These are the sort of people who constitute the vast army of breadwinners who carry life insurance in our country. These are the people who have made it possible for the American companies to place in force more life insurance than all the rest of the world combined. These are the people who have taken upon themselves the most stupendous financial obligation for the benefit of others the world has ever known. A more magnificent monument to unselfish thrift could not be conceived than the immense and growing volume of American life insurance.

But even in the operations of this great thrift-promoting institution we find striking evidences of the extravagance and improvidence prevailing among a large portion of our people. In contemplating the marvelous achievements of American life insurance, we are apt to overlook the costly obstacles that obstruct the path of its managers. Owing to a peculiar phase of human nature, the individual will not take the initiative. He will go to stores to buy the necessities and luxuries of life. he will go to the bank to deposit his money, he will even seek fire insurance, but he will not go to the life insurance office and apply for protection. Life insurance like religion must constantly be preached and urged upon him. He knows that he should have this protection, but it takes the most tactful and persistent pleading to induce him to act upon his conviction. The insurance missionary must call upon him anywhere from one to half a dozen times, a process which may cover a period of

weeks or months, before he will sign the application and appear for physical examination. And even after all this patient work, only a fraction of those solicited take insurance. Surely the life insurance thrift missionary is a most deserving public benefactor.

After the individual is insured, comes the difficult task of keeping him insured. The same improvident tendency which accounts for the reluctance of so many to take insurance induces these people to lapse or abandon it upon slight excuse. No more striking evidence of the spendthrift tendencies of our people can be found than in the waste resulting from the needless lapse and surrender of life insurance policies. It is true that many of these lapses are due to financial reverses, but the practise of a little economy would prevent the most of this loss which includes not only the insurance protection but the cost of putting it on the books.

Life insurance companies are deeply concerned in keeping this waste, for which the policyholder is responsible, at the lowest possible point, but long experience has demonstrated that it is one of the permanent unavoidable expenses of the business. The following table indicates the new business written and the old business lost by lapse and surrender during the past thirty years by companies reporting to the New York State Insurance Department:

Year	New Insurance Written, Millions	Insurance Lost by Lapse and Surrender, Millions	Ratio Loss to New Insurance (Per Cent.)
1885	$327	$123	37.6
1890	726	240	33.1
1895	769	418	54.4
1900	1,230	425	34.6
1905	1,562	644	41.2
1910	1,363	514	37.7
1915	1,928	818	42.4

It will be noted that the extraordinary progress of American life insurance has been made in spite of the fact that in many years, owing to the lapsing habit, it had to advance three steps to get ahead two. In some years the increase has been cut in half by the same cause. It is estimated that it cost the policyholders over 28 million dollars to put on the books the 818 million dollars of insurance which they voluntarily abandoned in 1915.

Another impressive evidence of the tendency of our people to succumb to the temptation to withdraw and spend savings which they have deposited, is found in the extraordinary increase in the money borrowed by policyholders from their insurance reserves during recent years. This is indicated in the following table which relates to all American companies:

Year	Loans to Policy Holders	Per Cent. of Loans to Reserves
1890	$19,903,242	3.0
1895	35,524,530	3.6
1900	88,500,575	6.1
1905	225,568,149	9.8
1910	495,099,854	15.4
1915	779,158,909	17.9

In thus withdrawing their reserves policyholders are in effect borrowing from the widow and orphan. Only about ten per cent. of these loans are repaid, and, therefore, must be deducted from the insurance money when the claim is paid. While this practise, which is now authorized by law, is a great convenience in time of financial stress, it also operates greatly to the disadvantage of the beneficiary, and, in a sense, neutralizes the purpose for which the insurance was taken. Moreover it is an encouragement to the wasteful tendency of the day and should be restricted to premium-paying purposes only.

It may seem idle to assemble statistics to demonstrate our most conspicuously obvious trait, extravagance, but the temptation to do so to impress the mind with the magnitude of the problem is not easy to resist. The following information may also assist in a better understanding of the institution of life insurance. The amount spent annually by our people for automobiles would give every married woman in the United States, rich and poor alike, $1,000 of life insurance protection. The money saved from a 30 per cent. reduction in the yearly consumption of intoxicating drinks, tobacco, jewelry and confectionery would give every married woman in the United States, $2,000 of life insurance protection. The total amount spent annually for intoxicating drinks would buy each married woman in the United States, $3,500 of life insurance. Every insurable person in the United States could have an average of $1,000 of life insurance by saving the price of a daily ten cent cigar.

It is equally interesting, and far more gratifying to try to visualize the wonderful contribution to human happiness which our people have made through their life insurance deposits. It may be well to note first a fact indicating the public-service character of the institution of life insurance. It returns nearly all of its savings and earnings to policyholders, as most of the companies are on the mutual or participating plan. The combined companies, stock and mutual, operating in the state of New York have returned savings and earnings as follows:

	Dividends	Per Cent.
In 50 years:		
To policyholders	$1,423,000,000	97.7
To stockholders	34,000,000	2.3
In 1915:		
To policyholders	106,065,500	98.7
To stockholders	1,446,729	1.3

into the domestic life of the people nor the extent to which it has developed and built up the country, and now sustains the machinery of civilized life.

Consider first how widespread in the commonwealth is the insurance of lives. At the end of 1915 there were 43,133,415 policies in force in the United States and Canada, as compared with a population of, say, 110,000,000. We estimate that these forty-three millions of policies were upon twenty-five to thirty millions of lives, and therefore that about a quarter of the population is insured. These are the figures of 244 regular reserve companies. The insurance in force was $23,756,-472,828. The companies are exceedingly active and energetic in prosecuting the business. There was a gain of nearly two and three quarters millions in number and nearly one and a half billions of dollars in amount of insurance in force during the year 1915. To realize the significance of these figures, consider, next, what life insurance is. Fundamentally it is the association of numbers of people who realize that while nothing is more certain than death, nothing is more uncertain for each healthy individual than the date of death; that death is a pecuniary loss to the dependents; that there is a necessity to tide over a period during which new adjustments can be made in the lives of the survivors; that for this period assistance is needed. The contributions of these numbers of people go into a fund out of which this help is furnished. Though the date of the individual death is uncertain, the number of deaths in the year among the contributors is quite certain. There is therefore a mathematical relation established between the amount agreed to be contributed and the amount of the fund to be drawn upon death. The uncertainty of the date of death makes life insurance a very human thing. It used to be called a gamble. Surely it is not that. We have a right, after all these years and the tremendous extent of life insurance, to say that the system is the result of conscious mutual helpfulness. It is a social institution. The family which draws a death benefit after a single premium is not drawing charity. The obligation of the holder of the policy was undertaken in good faith with the view of helping others, and the help from others arising from the unexpected death is the mere fulfilment of an obligation which was reciprocal. No doubt when a man insures his life he does it to protect his family in the event of his death; but he neither expects nor desires his own death, and has he not at least a subconsciousness that he is making a mutual bargain to give or take help as the event may prove? Thirty-five out of the forty millions of policies are held in mutual companies. There is something very impressive from the point of view of social economy in the banding together of these millions of people for mutual protection; something very impressive when you think of their yearly mutual contribution of nearly a billion

of dollars, seventy-five per cent. of which immediately passes into circulation, and twenty-five per cent. of which goes into circulation through interest-bearing investments. Life insurance is therefore a brotherhood whose operations are intensely practical. These companies distributed during 1915, $580,121,669—over one half of the national debt. Think of the excitement the government would arouse if it undertook to pay its debt in a single year! Think of the taxation necessary to enable the government to do such a thing! Yet the distribution by life companies of over half á billion dollars in a year causes no comment. It enters into the common life of the people, affecting enormous numbers of them. We may take it that this money went to the families of nearly a million persons, and therefore affected four or five millions of individuals. And this is an *annual* experience. Multiply it by ten years, and consider what a common daily experience is the knowledge by our people of the results of this system of association for mutual help.

It would be mere commonplace to dwell upon the good done by this enormous distribution of money, in relieving want, paying debts, furnishing future support.

Let us go back to the fund out of which these payments are made. It is stupendous in amount. The assets of these companies at the end of 1915 were $5,485,307,895. They increased during the year $257,-176,467. There were poured into this fund during the year $1,102,-782,532, of which $823,106,490 were from premiums. Of the total assets there were permanently invested in reserve required by law to meet policy obligations the sum of $4,592,921,199; the increase in the reserve during the year 1915 was $251,232,545. These figures are so large as to benumb us if we look at them as mere accumulations. We must consider how intimately into the daily life of our people these millions and millions of dollars enter. In no other way may we appreciate the extent of the service performed.

Take the five and a half billions of assets. It is probable that thirty per cent. of these are invested in railway securities, that is, over one and a half billions of dollars are in the real and personal property of railways. The first thought about this is that the insurance business has been the most important single instrumentality in developing the country; that millions of acres of land have been thrown open to cultivation; that has brought in population for agricultural work; these must be housed, fed and clothed; the crops must be shipped away; then we see towns grow about the stations to forward the freight and to sell the food and clothing to the farmers' families and the railway men. Mills follow to bring manufactured articles nearer to the consumers. Thus gradually cities grow up, all business increases, more money circulates. In short, the crops, the coal, the ores have been wealth added to the country's resources; enormous populations have been scattered over the various

states; the resulting commerce has founded and built up the cities of the country; and through exports, money has been drawn from all the world and millions of people invited to our shores and sent throughout the land.

It is probable that thirty-five per cent. of these assets are loaned on bonds and mortgages. That means that communities have been built up by insurance funds. It is estimated that ten per cent. of the funds are invested in state, county and municipal bonds and bonds of public improvements. That means that communities have been developed and sustained, and have been furnished with the conveniences of modern life and with material facilities for the education of children by the insurance companies. This constructive work is continuous. Under the reserve system of insurance, more than four fifths of the assets are subject to reserve liabilities—the total reserves of the companies amounted to over four and a half billions of dollars at the end of 1915. The investments are stable. They increase automatically, like the rolling of a snowball. More than three quarters of the semi-annual interest receipts are added to the reserve and in turn invested and held. Moreover, the investments are made where they are most needed. This arises from self interest, because obviously the best rate of interest is obtained, as a rule, where capital is scarcest. Fourteen companies have nearly a billion of dollars invested in the west and south.

Probably fifteen per cent. of the assets of the companies are invested in policy loans. Leaving aside the question whether it is wise for either the company or the borrowing policyholders that there should be so much lending, it must be admitted that the loans associate company and policyholder closer together; that the return of over eight hundred millions of dollars collected in premiums to those who paid them, and while they are continuing their policies, means an increase in capital resources; that the business and social life of the individual are profoundly affected. He *spends* the money borrowed. If he pays future premiums with it, he keeps his family protected; if he pays debts, he releases capital and carries easier the burden of life; if he buys luxuries, he thanks insurance for his keener enjoyment; if he tides over loss of income, he realizes as never before the blessings of life insurance.

Let us go deeper into the relation of insurance to the industrial life of the people. The income in 1915 of the 244 companies was over a billion of dollars, of which over 800 millions were in premiums. Of this billion dollars of income ($1,102,782,532), twenty-five per cent. was added to reserve—$251,232,545—and invested in the upbuilding of our material resources; fifty per cent.—$580,121,669—was returned to policyholders new and old. Want relieved, families supported, children educated, debts paid, investments made for widow and children—the blessings of life insurance have so often been explained that I need not

pursue that topic; sixteen per cent. went to management expenses—salaries, wages, commissions—touching the community on all sides as money spent in small sums inevitably does; about one and a half per cent.—say, sixteen millions of dollars—paid in taxes on premiums, an amount we may say unjustly assessed upon thrift, but which went to lighten the burdens of other taxation and contributed to the carrying on of civilized life, protection of property, education, caring for the sick.

Perhaps one gets a clearer conception of the economic service of life insurance when he studies the business of industrial life insurance. Three quarters of all the policies in force are industrial—thirty-two millions out of forty-three. When one thinks of the service performed, the number of individuals affected is perhaps more important than the amount. Is it not a startling fact that one out of every five of the population of the United States and Canada holds an industrial life insurance policy and weekly pays his premium to a collector? Can any one institution be said to be as close to the people as that? When you consider that in Philadelphia and some other cities there are more industrial life insurance policies in force than the number of the population, you begin to get an inkling of how close to the life of the people life insurance is.

One hundred and fifty-six millions are annually collected in weekly installments. This involves eight and a half millions of visits weekly by agents—over four hundred millions of visits annually. The agent performs all the services required by the policyholder—he collects the premiums, pays the dividends and bonuses, calls to prepare the proofs of death and later to pay the claims. The agent enters into the daily family life of the wage-earners. He knows all the family, their joys and griefs, their income and outgo, their pleasures, their work—their very *life;* is often their adviser, confidant and friend; and always in a representative capacity; he is what he is to those millions of people because he to them *is* the company; they know the company is back of the agent; agents may change, but the company is always with them. People pay premiums to the agents and the collections go to the insurance fund—the assets; the assets are invested; part of them go to railway treasuries; part to governmental officials; part to treasurers of public utility companies; part to personal borrowers on mortgages. But these recipients do not keep the money. They spend it in materials and wages. The materials, moreover, had to be manufactured by wage-earners. In the last analysis, the people who pay the premiums get the premiums back in wages. It is the workman who gets metal and coal out of mines, who clears forests, who fashions lumber, who gathers crops, who makes brick, who quarries stone, who draws rails, who casts structural steel, who erects buildings and lays railway lines and builds locomotives and cars. For all these things he gets paid out of the assets of insurance companies

invested in the debts of his employer. And when he gets his wages he buys food and clothing, and this involves more buildings and more railways and more cities and towns and more means of communication and more public utilities. And with part of his wages he buys insurance and pays his premiums and increases the companies' funds. Thus, money he pays to insurance companies comes back to him in wages. An endless chain? No. It is circulating blood. It carries on the life of the people. Service? It is *civilized life!* From the cradle to the grave industrial life insurance is the companion, servant, friend, benefactor of the wage-earning families. It makes of these people a capitalistic class. No one of them can buy a bond, but two hundred of them can do so every year, for their collective industrial premiums will then have amounted to $1,000. A million of them in ten years will contribute enough to build a railway halfway across the continent; or to put up fifty large city schools; or to run a subway through New York; or to supply a large city with water; or to build 20,000 homes for a hundred thousand people—build a city! It is not only that they *can* do it—they *do it!* Consider the assets of the industrial companies—eleven hundred millions of dollars!

A recent progressive stage of life insurance which has economic interest is what is practically the care and investment of savings for the surviving dependents; an end achieved by the deposit of the proceeds of a policy with the company which pays interest, or the payment of the policy in many installments. The amount of insurance on these plans is rapidly increasing. This is a service which saves dependents from errors of judgment and exploitation by unwise and designing advisers.

One large and old life insurance company is issuing millions of insurance to employees covering a burial fund for the employee and weekly support to the dependents; the premiums paid by the employer. Another prominent company issues policies providing sick benefits, accident indemnity and burial fund. These policies may be collective, issued to the employer, with or without contributions from the employee. Two other companies insure their thirty thousand of employees against sickness and death.

One or two companies are offering mortgage loans on homes, with provision for amortization protected by life insurance; a form of service of the greatest benefit to the community as well as to the insured.

The latest development of life insurance in this country is interesting and, to those who know the history of this business, really amazing. It is distinctively American, for it is seen in no other country. It is doubtless the outgrowth of the sentiment which of late years is pervading society throughout the world, and in this country especially has involved industrial and commercial business: the sentiment that there is a responsibility resting upon the prosperous to help the less fortunate; that

there is a duty to the community to better conditions and uplift the mass. As life insurance is based upon mortality, it is a logical working out of this sentiment for the insurance companies to do something to lower the death-rate—to conserve health and lengthen human life. It is the same sentiment which leads manufacturers to improve conditions of labor and domestic life of wage-earners and to promote thrift.

This new service which life insurance has begun runs along several channels, and we may well take a brief survey. In a paper widely distributed at the 15th International Congress on Hygiene and Demography held three years ago, Mr. Cox, manager of the Presidents' Association, composed of about thirty life insurance companies carrying seventy-seven per cent. of the American policies, noted that there was a group of five companies, with twenty-two millions of policies, that were making special efforts to stimulate their policyholders to personal and public hygiene; that there was another group of four companies which advised impaired applicants for insurance as to their physical condition and made suggestions to aid them. Another company provided for free periodical medical examinations of its policyholders. Another had formed a health association among its members. The Presidents' Association itself opened a forum a few years ago for the discussion of things intended to prevent disease; and papers were read by Professor Fisher, of Yale; Dr. Foster, of the St. Paul *Medical Journal*; Dr. Wyman, surgeon-general of the United States Health and Hospital Service; Dr. Rosenau, of the Harvard Medical College; Dr. Porter, health commissioner of New York state; Dr. Doty, health officer of New York City; Dr. Wilbur, of the Census Bureau, and Dr. Dwight, of the New England Mutual Company, on such subjects as the Economic Aspect of Lengthening Human Life, Increased Longevity of Policyholders, Work of the Federal Government in Health Conservation, Preventive Medicine, Fight against Preventable Diseases, Modern Sanitation, etc. The American Life Convention had addresses by experts on Forces against Mortality, Mortality from Diseases of the Kidneys and Circulatory System, the Short Life History.

A Life Extension Bureau has been formed, patronized by several companies, which examines insured persons and communicates the results to the family physicians, the cost defrayed by the companies. One life-insurance company has thus had examined fifteen thousand of its policyholders.

One company with nearly thirteen millions of policies in force has issued large numbers of pamphlets and leaflets on health and disease to its policyholders and has an expert constantly studying morbidity from many points of view, especially occupational diseases, and publishes the results.

Another company, with over sixteen millions of policies, has an

elaborate system of education and of fighting disease and ameliorating sickness. It has circulated one hundred and forty millions of pamphlets, leaflets and magazine articles in several languages upon such subjects as Tuberculosis (six millions), Care of Children (two and a half millions), Teeth, Tonsils and Adenoids (same number), Health of the Worker, Care of Babies (six millions), Milk (five millions), Flies and Filth (six millions), Typhoid Fever, Scarlet Fever, Diphtheria, Measles, Whooping-cough, Cancer, Pellagra, Hookworm, Infantile Paralysis, Smallpox, and has distributed thirty-four millions of paper drinking-cups. It exhibits health educational booths at county fairs, as many as 125 in a year. It assists health officers in clean-up campaigns in over 250 cities. It has made surveys of several large cities to discover and tabulate the amount and causes of sickness. It has helped the authorities to enforce housing laws; distributed ballots on votes for municipal sanatoria and additional school houses; cooperated with anti-tuberculosis societies; agitated in legislatures and among health officers for systematic and accurate vital statistics. It has cooperated with the federal government in a survey of unemployment in 44 cities—a survey covering three millions of lives. Its most remarkable work on lines of health is a system of furnishing free the service of trained nurses among sick policyholders, whose visits number a million a year; the nurses attend the sick and give instruction to the families in hygiene. Over six and a third millions of these visits have been paid. It has entered into a kind of partnership with two states to get trained nursing to every sick inhabitant. The company has built a sanatorium for tuberculous employees and is building a rest house for convalescents from other diseases. The sanatorium is a center of study of the White Plague, its prevention and cure, and carries on correspondence and reciprocal visits with like institutions. Of about 500 treated, including those still in the institution, it has discharged as cured (or arrested and quiescent cases, as physicians say) 35 per cent. in two years' work, although at the start over 8 per cent. of the cases sent were far advanced, 61 per cent. moderately advanced, and many are still under treatment. It is now paying for the work of taking over a whole town, making a survey to determine what inhabitants are infected with tuberculosis, then of isolating the patients, nursing and treating them—in an effort to find out whether such work will result in stamping out tuberculosis altogether from the community. Altogether the company spends more than a million dollars a year in welfare work. The company medically examines its twenty thousand agents and employees annually for the discovery and treatment of incipient disease.

It seems to us that the best thought of the age has fixed upon insurance as the solvent for most of the economic ills of society. One can in imagination picture the time when instead of one in every five, four in

every five of the population shall be insured in mutual companies; and in the development of these companies along welfare lines which is now in its infancy one may look to the time when the people shall take care of themselves through life insurance in a service covering health in life, care in sickness, indemnity in death, sanitation in community life, the financing of home-owning, of public utilities and civic conveniences—a mutual service of cooperation among such a large proportion of the population that it may be called The New Socialism!

RECENT DEVELOPMENTS IN THE LIFE INSURANCE FIELD

By ROBERT LYNN COX

GENERAL COUNSEL AND MANAGER, ASSOCIATION OF LIFE INSURANCE PRESIDENTS

THE topic assigned to me on this occasion seems to be a call for the latest news of the life-insurance business.

I am asked to play the rôle of reporter.

But what I have to say will not be startling or important enough to cause the Friday papers to issue extra editions or the Saturday weeklies to hold their presses in order to get the story.

Life insurance has passed the experimental stage. Development in that field is no longer classed among discoveries. Progress here is merely growth—steady normal growth. Who can become excited over such a thing as that? Even the chief ailments of this business have run their course or been cured. State supervision provides physical and moral examination of every company at least once a year and official X-rays are used on nearly every important transaction.

Oh! Life insurance, like mankind in general, is pretty well protected now-a-days against germs and accidents.

But, like mankind again, the dangers which threaten are the degenerative diseases. Statutory regulation in too great detail is threatening it with hardening of the arteries, that ailment hitherto confined almost exclusively to governmental functions. Excessive taxation is weakening its heart action.

There appears to be some danger that the public may not awaken to the situation until the patient is beyond help.

We sometimes forget that an institution which has sprung from economic needs and has continued to flourish for years without governmental aid must have in it that which satisfies widespread human desire. And if it has, it is entitled, as an institution, to the kindly consideration of the public at large. If error has crept in, the public interest calls for reformation rather than destruction. One of the chief dangers that

threatens society to-day is the custom of viewing minor social faults with distorted vision. At the very time when we are learning that environment has so much to do with sin and crime, that reform and not punishment must hereafter be the watchword in dealing with *individual* infractions of the law, we forget that environment has likewise been the chief cause of *business* sins and misdeeds and that here too we need reform rather than capital punishment. In the day when so much is being said about the need for conserving our natural resources, may I not suggest the importance of conserving those artificial resources consisting of the business institutions created by man to meet his economic needs?

If we can learn anything from the rapid changes in our economic surroundings, it is that the individual is becoming more dependent upon others whom he does not know personally and less independent in his relation to society as a whole. In other words, he is being submerged in the social organism with little or no chance for independent existence. Though he may struggle to preserve to a degree his individuality, yet in the end his happiness is going to be determined more by the attitude of his fellowmen toward him, than by what he can do for himself alone. This change of economic relationship is finding its manifestation in cooperative movements of all sorts.

Life insurance has an important relation to this changing condition of the individual, which we may as well call progress, since it represents a world-current from which there seems to be no possibility of escape.

In the beginning the economic disturbance caused by the death of a breadwinner fell upon his immediate dependents. But with the knowledge that the death rate was subject to the law of averages, it became possible, through life insurance, for men to largely absorb the economic shock in the individual case and distribute it among the living.

It has shown how men themselves can provide for the helpless and protect the weak without appeal to charity and without reliance upon governmental paternalism. It stands as one of the few living examples of cooperative movements that have succeeded, showing that if organized on business principles and placed under competent management co-operative effort can render the best of public service.

While life insurance is necessarily cooperative in principle, it has been worked out on a business basis, which means that benefits are proportioned in each case to the obligations assumed and borne by the policyholder. As a self-sustaining, independent organization, it could not have lived under any other plan. Each policyholder is given as much as he pays for and no more. Though the institution provides for the needy in its general results, it is business-like and just in apportioning its burdens and making its returns to the insured. This is a natural result of conducting it as a business affair where the doctrine of "money's

worth" must prevail as distinguished from party affairs in which "political worth" is what counts. Incidentally, the success of this institution points the finger of shame at the scandals of mismanagement and corruption in governmental affairs, showing, it would seem, how much greater efficiency and honesty can be expected under a system that is not subjected to the uncertainties and upheavals incident to political office with the scheming that is necessary to secure and retain political position.

From the standpoint of present policyholders, life insurance is co-operation in the matter of adjusting death losses between people of a selected class. It is a grouping for insurance purposes of those who are free from serious physical defects so far as can be ascertained prior to their admission to the groups—of those who are able and willing to pay their respective shares of the expense involved. They expect no favors and will tolerate no discrimination.

Should the time ever come when life insurance is brought under political domination, through undue extension of supervisory power or otherwise, I hope it will not happen until we have achieved such perfection in our governmental organizations as to make certain that vote-getting ability will not be substituted for physical fitness as the test for admission to insured circles. While it may be argued that those who need life insurance most are the lazy, the impecunious and the diseased, yet those who are not thus classified, but are insured under existing conditions, can not fail to see how their burdens would be increased should insurance doors be thrown wide open. If society at large must carry the weak and unfit, as, of course, it must, surely it can be done far more economically through public institutions and other devices of modern civilization planned especially for the purpose, than in an attempt at universal insurance, providing for the payment of money to the improvident *with no check upon the habit of improvidence* which has largely been responsible for their dependent position.

It is well to think of these things in days when so many well-meant, but impractical, insurance schemes are being urged upon the public for immediate adoption.

While the pendulum of human action doubtless must continue to swing from one extreme to another, I would like to remind those who stand with heart alone at one end of the arc, and likewise those who stand with head alone at the other end, that the release of mechanism which takes place at the point midway between the two is what makes for real progress. For this reason my plea is not for brain only, such as developed to a marvelous degree the business activities which characterize the last half century of our civilization, nor for sentiment alone, which to-day seems to dominate our thinking in regard to what should be done to remedy existing defects in our social organism, but rather for

a combination of the two, *in* which alliance I believe it will be found possible to retain our business efficiency which has become the marvel of the age, and yet have it used in the interests of humanity as a whole.

Life insurance stands to-day at the head of institutions making their appeal to manhood and independence, by offering a practical method of escape from the economic catastrophe which threatens every bread-winner in greater or less degree. It may, therefore, be said to be an institution of progress thoroughly in accord with present-day desires to take the load from shoulders unduly burdened and put it upon those who can better afford to carry it. It was organized to do just that and it is doing it.

I know there are some who do not regard this institution as being at the forefront of the world's progress because it is not of recent origin. To them I would suggest that old things are not necessarily reactionary (whatever that means), though frequently characterized as such. The farmer who raises wheat is not reactionary because he is doing that which was done by his ancestors before him; likewise, he who manufactures clothing is not reactionary simply because he is doing that which has been the business of some one since the race began. Both are contributing to the world's progress, though following in well-beaten paths. Likewise, life insurance is marching with society, using the lamp of experience to light the way ahead. We must discriminate between enterprises and institutions on some other ground than age and size, though there is a tendency nowadays to decry everything that is large and most of that which is old.

The great and important work done by life insurance is, and must always be, that of alleviating the distress and absorbing the shock caused by the death of a wealth-producing member of society charged with responsibilities of caring for others. And as we come to see more clearly that all such disturbances are matters of public concern, we will the better understand why life insurance has led and will continue to lead as an important factor in economic affairs.

Life insurance under alert and active leadership has always proved itself ready to enter new fields and to serve new needs. Under partnership insurance each partner is insured against the death of the other in order that the business established and successfully carried on by their combined talents shall not be financially crippled and perhaps destroyed by an unexpected and unpreventable dissolution of the firm. Very similar in usefulness and effect is what is called corporation insurance, under which great business institutions are protected financially against the disturbance that would necessarily follow the untimely death of the managing genius of the institution. So too, banks, and other lenders of money who are accustomed to look for security more to the personal character and reputation of the borrower than to the property he may

own, are asking for insurance upon his life as protection against the only contingency they fear and the only uncertainty they need to provide against. These are comparatively new fields for life insurance activities, showing that as a new need is developed the men in the business prove themselves ready to meet it.

Again, we see it coming forth with protection against great evils as they developed from time to time. We have all read recent reports of the federal prosecution of gigantic fraudulent investment schemes under which millions of dollars have been filched from small investors of limited experience. The most fertile field of operation for such swindlers is among those who have suddenly come into possession of legacies or perchance of insurance funds. Life insurance companies can not protect any except its policyholders, but this it began doing long in advance of the recent disclosures to which I have referred, by providing a policy which would pay a fixed monthly, quarterly or annual income to the beneficiary instead of paying a lump sum that would impose on the recipient the burden of investing it safely and satisfactorily. I do not need to explain further in this connection to show you how here again this great institution has been keeping up with the needs of the times and is making itself a factor in the world's progress.

The adaptability of the modern life-insurance policy to present and prospective needs of the insured, whether certain or contingent, is a matter of amazement to those who are unfamiliar with the subject. While the company is bound hard and fast to its contract, the policyholder can continue it as long as he likes and if he decides to withdraw can take out whatever surplus fund remains to his credit, or, if he prefers, take his money's worth in paid-up insurance. The company's only hold upon him is the retention of his confidence through fair dealing and just treatment. Is it not marvelous that under such a situation, taken in connection with the modern tendency to unduly magnify evils and weakness, that the business has not only held its own, but continued to flourish to a greater degree than other large business institutions?

We are learning that life insurance can render many incidental benefits. Perhaps the latest to attract attention is that of its service to the cause of public health, or as translated into life-insurance terms, the prolongation of human life.

In the earlier days of the business it was thought that to apply the law of averages and to compute and collect premiums high enough to provide for payment of death claims was all that life-insurance companies should be expected to concern themselves with. But now men engaged in this business conceive it to be a duty to devote and find pleasure in devoting a part of their time and energy to the campaign having for its purpose the prevention of preventable diseases. The connection of life

insurance with this movement might be compared with the transportation of goods and passengers over country roads. At first attention was devoted to constructing springs that would absorb the unevenness of the highway. But now we are coming to understand that it is cheaper and better to remove the stones and fill the ruts in order that springs may be needed less frequently. In other words, instead of devoting our energies wholly to the perfection of devices intended to absorb the shocks, we are now thinking more of removing or preventing the things which cause the shocks. This is a homely comparison, but illustrates fairly well why life-insurance companies and others are now taking part in the various campaigns having for their purpose the prevention of disease and needless death.

I will not take the time to rehearse in detail how much is being done by life insurance companies along this line. I must be satisfied in stating to you that nearly every large company in the United States is doing something intended either to prolong the lives of its policyholders or of the people generally.

Assuming, as I think we must, that advancement in the welfare of society as a whole is the test of what shall be deemed progress in the world, can there be a doubt that life insurance is to-day playing a leading part in it? And though we put aside the main contribution, it has made toward the lessening of human misery, do we not see that even in its secondary functions, to some of which I have briefly referred, it is doing much to solve the newer questions of the day, questions that will increase in importance as population multiplies and society becomes more complex? As the public becomes interested to a greater degree in cooperative efforts and in a wider measure of unselfish devotion, is it likely to find another institution affording better evidence of what can be accomplished in this direction or which could as well serve as a model for others to follow?

To me the hope of the future lies in the fact that religion and ethics and business are no longer being carried in separate airtight compartments of the human mind, but are freely intermingling to the great improvement of each. The need for the observance of moral principles throughout seven days a week, instead of confining it to the doings of one day, has become a popular doctrine and is generally commended. Now we seem to be reaping the natural harvest of having business take up for solution the economic problems involving ethical principles. This means that business, with its habit of getting results, with its wealth of training and experience, with its eye for the practical, has been enlisted in a new cause. As I see it, business with broader motives and higher ideals is likely to become the most potent factor in bringing about the reforms that are needed to make this world a fit habitation for our brothers of to-day and for the generations that are to follow them.

So, I say, let us not destroy the business agencies now serving our social needs nor sacrifice wholly the efficiency they have developed under the impelling human desire for personal gain. Let us, instead, continue the movement, already well under way, of putting into our business activities the spirit which makes personal gain an incident and service the real motive. Such a result has largely been accomplished in the life-insurance field and is the most important of its many recent developments.

LIFE INSURANCE AND LIFE CONSERVATION

BY EUGENE LYMAN FISK, M.D.

MEDICAL DIRECTOR, LIFE EXTENSION INSTITUTE, INC., NEW YORK

WHICH is the greater public service for a life-insurance company to perform: to pay a $10,000 claim to a widow and children, or to keep alive a $100,000 husband and father? This is putting the question in a crudely materialistic way that invites an answer in dollars and cents, an all too common quantitative American method of valuation. Yet it is by such concrete mathematical expressions of the financial value of a man that we can most successfully arrest attention and focus it on the appalling waste of human life.

It would be difficult, indeed, to exaggerate the opportunity and obligation of life insurance as an institution for the prevention of poverty, as a conservative mechanism for maintaining the stability of the family and enabling those of moderate means to acquire an estate at the expense of a small annual outlay, but as we felicitate ourselves on the economic value of the life-insurance policy at a time of bereavement, on its wonderful power to meet the trying emergency created by the loss of the breadwinner, let us halt for a moment and ask the question: Was the loss, which no money payment can really make good, an inevitable loss? Was it due to some fault in our social organization that permitted a life to pass over the precipice without a warning? Did the great institution of life insurance neglect any opportunity to set up a warning, to furnish life-guidance that would have turned the policyholder away from the precipice? Has it done all its duty and fully utilized the machinery at its disposal by providing an ambulance and a splendid funeral at the bottom of the cliff over which the policyholder plunged unwarned?

The answer may be that the purpose of life insurance is to insure, not save, lives; that society provides other agencies for such purposes.

To that it may be replied that this is an age when opportunity for public service is held to impose an obligation for its performance, when

the scientific organization of business activities demands that there shall be no lost motion, no wasted by-product.

There is now held by the old-line life-insurance companies of this country about $5,000,000,000 of assets for the protection of more than 40,000,000 policies.

This immense business mechanism, in periodic contact with practically the whole wage-earning population, enjoys unusual opportunity for reaching the mass of the people with the message of personal and community hygiene, of how to live so that life shall be most worth living and not prematurely snuffed out.

To put behind health conservation and health improvement work the right kind of effort, we must commence with the acceptance of certain premises and fix certain ideals as to ultimate accomplishment. The physical changes usually ascribed to time we must recognize as due to poison or infection or starvation or trauma or emotional strain, all factors to some degree under the control of man. We must look upon old age and death as provoked phenomena.

It is not time that we have to defeat in seeking to prolong human life, but activities that adversely affect our tissues in the course of time. Time itself is a mathematical abstraction; it does not govern the death-rate, and death-rates are not fixed by any immutable law, even that of heredity. There is no effect without a cause; and whatever factor there may be aside from those I have enumerated that is responsible for old age and death, it will be found to be a material cause subject to some form of modification or control.

Medicine is beginning to emancipate itself from the thraldom of terminology as applied to disease. The conception of disease as an entity, as a progressive process to which a man is condemned in some mysterious way, is still in some degree exerting its influence over the attitude of medical science toward the human body; but as one "disease" after another is shown to be the result of an infection or starvation (food deficiency) or emotional excess, or a poison from within or without, we come to view "diseases" merely as tissue changes or persistent functional disturbances due to the operation of these definite influences, and we appreciate that if the body is protected from these very definite antagonistic influences the so-called disease disappears, except so far as it has resulted in permanent impairment of tissues. So that a man who is either ill or growing old is merely one whose cells and organs are breaking down or disturbed in their relationships by factors to some degree under the control of science.

To what extent the complete revelation of bodily defects and their causes and the complete utilization of present scientific knowledge for the correction of bodily defects and of faulty bodily care may lengthen human life, is a matter that affords abundant exercise for the scientific

imagination. At least a long step will have been taken toward improved conditions when the postulate is accepted that the death-rate is not subject to rigid law, but to controllable conditions, when it is universally conceded that the field is open and that it is not limited either by the Psalmist's threescore years and ten or the American Experience Table, or any other formula merely derived from experience under conditions that are neither fixed nor necessary.

Three Years' Progress

At the meeting of this section in 1913, it was my privilege to read a paper on this subject, in which the possible functions of the life-insurance company in conserving the health of the people were outlined and the already existing activities were described. Since then there has been a strong growth of sentiment in favor of conservation work by the life companies and a very considerable extension of these activities, foreshadowing an ultimate complete utilization of the available facilities for prolonging and improving human life. Much, however, remains to be done and there is an immense field yet uncultivated, as the following analysis of the health conservation work now being done by the old-line companies will show.

In response to a questionnaire set to all old-line companies in the United States and Canada, I find the following conditions:

Two hundred and thirty-one insurance companies were circularized, of which number 119 responded, as follows:

	Ordinary	Industrial	
48 companies with ..	3,869,789	597,536	policies are doing nothing
32 companies with ..	621,114		policies are doing nothing but are favorable to plan and contemplating action
12 companies with ..	640,190	2,559,581	policies are occasionally sending out health literature only
3 companies with ..	152,391		policies are regularly sending out health literature only
23 companies with ..	4,293,132	27,316,532	policies are giving some form of periodic health examinations to some of their policyholders
1 company with ...	21,991		policies are sending out periodic health bulletins and giving periodic examinations to all policyholders, as a policy provision
Total 119 cos. with..	9,598,607	30,473,649	policies

112 companies have not as yet been heard from.

In January, 1914, the Life Extension Institute was organized for the purpose of developing a specialized organism for carrying on work

of this description, on the basis of a self-sustaining public service institution, with a board of 100 advisers, among the world's leading scientists, that would safeguard its educational and scientific policy.

The institute aims to collect data regarding personal hygiene and to encourage a proper application of such knowledge by providing a periodic examining service, so that the particular needs of the individual may be ascertained and the rules of hygiene be applied with precision.

The Metropolitan Life Insurance Company, the Germania Life Insurance Company, the Connecticut General, the Postal Life Insurance Company, and the Aetna Life Insurance Company have extended the benefits of the service to a considerable body of policyholders.

Among other leading companies that are moving in this matter may be mentioned the Equitable Life, which has within the last two years, in addition to issuing health bulletins to policyholders, extended the privilege of a periodic health examination to policyholders in the larger centers, and a urinary analysis to others.

The Penn Mutual is experimenting along similar lines in Philadelphia and is planning an extension of the work. The Prudential has issued some health literature, besides making many contributions through its statistical department to the study of mortality conditions, and has lately extended to a large body of its policyholders the privilege of sending urinary specimens to the home office laboratory for examination, in order to determine the early signs of kidney trouble.

The Metropolitan Life has engaged in the most extensive and diversified health activities among its policyholders, involving a vast expenditure for their benefit. These include a nursing service for industrial policyholders, the distribution of many pamphlets on personal and community hygiene, for its policyholders and for general circulation, many contributions to statistical and social science by its scientific departments, the service of the Life Extension Institute for ordinary policyholders, and lately the contribution of $100,000 for a community experiment, in cooperation with the National Association for the Study and Prevention of Tuberculosis, for studying the prevention of tuberculosis and the conservation of health generally by means of thorough individual examinations, laboratory work, etc., in a particular community, which shall later serve as a unit expression or exhibit of methods that could be applied throughout the country. Also, the company maintains one the finest sanatoria in the world for the treatment of tuberculosis among its employees.

The amount of good done by such agencies can not be represented solely by the direct influence on those who have been served. The universal stimulus given to health conservation work by the Metropolitan's activities probably exceeds in value the direct benefits conveyed to its policyholders. The utilization of these opportunities for enlightening

the public on the laws of hygiene has been shown to be in accord with a practical and feasible, humane and sound business policy, which has been put into effect without any embarrassment or disturbance of the regular function of life insurance and with undoubted immense benefit to policyholders and to the public.

In my former paper before this section I referred to the three years' experience of the Postal Life on a group of policyholders who had taken these periodic examinations and the apparent saving of life that had been effected among them. It was estimated by their actuaries that for every dollar of expenditure there had been a reduction of mortality representing a saving of $13.00. This experience is now of about seven years' duration, and a recent analysis shows that these favorable mortality conditions still continue, so that the former figures can not be regarded as a fortuitous fluctuation.

A seven years' exposure of $11,000,000 of insurance, average age 51, and 40 per cent. of the risks found impaired to the extent of being substandard, showed a mortality of 80 per cent. of the American table. These were mostly old risks, long insured, taken over from the Provident Savings Life. The general mortality of the Postal has shown peculiarly favorable mortality movements which are ascribed by the management to the general health propaganda. In this company all policyholders are entitled to the privilege of yearly health examinations as a provision of their policy contract, and all receive the health bulletins issued at intervals throughout the year. Many that do not take the examination are undoubtedly influenced to go to their own physicians and otherwise benefit by the suggestions received. The mortality of the Postal Company, apart from its reinsured risks, in the tenth year of its existence is 29 per cent. of the American table.

The Germania Life Insurance Company has published the following figures and comments regarding the examination of its policyholders by the Life Extension Institute:

A study of a group of examinations of Germania policyholders completed during 1915 by the Life Extension Institute brings out some striking facts.

Only 1.21 per cent. passed a perfect examination, that is, no physical impairments were found and no advice for correction of living habits was needed.

The individuals found imperfect, either in physical condition or manner of living, were graded as follows:

	Per Cent.
Seriously affected	4.25
Moderately affected	64.12
Slightly affected	30.42
Total	98.79

Of those referred to physicians (68.37 per cent.), 20.27 per cent. were aware of impairment.

The inference seems justified that from the standpoint of physical well-being the lives of these policyholders were made more livable and that Health Service lengthens the lives of policyholders.

(These figures may be taken as closely approximating the results found in other large groups examined by the Institute, and fairly exhibit the average conditions that offer opportunity for conservation measures.)

These figures differ in degree from those exhibited in my paper before the section in 1913. The group then reported on showed only 40 per cent. of impaired lives, and among them 44 per cent. were unaware of impairments. The much higher proportion of impairments found by the institute, and the larger percentage of those unaware of such impairments, simply reflect the development of a much more extensive and highly standardized system and a continually improving technique among the examiners.

Having secured the cooperation of the examiners throughout the country, the institute has called upon them for a critical and thorough survey of the body and has appealed for a standardization of system and technique which has met with a very gratifying response.

If the comparatively crude and tentative methods followed with the first group of policyholders ever subjected to such a system has resulted in so emphatic a saving of life, what may be expected from a far more rigorous and searching examining system, coupled with a more careful review of the living habits of the policyholder, a full report to him and to his physician, and an extensive educational service provided by special leaflets dealing with the policyholder's personal needs?

Many individual instances of health improved and lives saved by this system are on record, but a statistical statement of the results yet remains to be made and involves many difficulties because of the critical analysis to which these lives have been subjected and the difficulty of classifying them in the light of the new knowledge developed by this work and by the more exact technique employed. As a three years' period will soon be completed, we hope, with the cooperation of the companies having contact with the institute, to work out the problem and secure a preliminary statement of the influence of this system.

Incidentally, the Life Extension Institute is laying under a heavy obligation even those insurance companies which do not take its service, in that in our examination of commercial and industrial groups we are continually discovering impairments among thousands of life-insurance policyholders and assisting such policyholders to prolong their lives.

Urgent Need for Conservation Work

One significant fact, however, awaits no further demonstration; namely, the widespread need for such work, not only by life insurance companies, but by all agencies through which the people can be reached,

and possibly in the final analysis by the government itself. There is no need to wait for government action. Certain economic principles involved make it possible for this tremendous influence for national preparedness to be put in motion as a sound and saving business policy for every one who practises it. The insurance company strengthens its policyholding body, its greatest asset, and reduces its mortality rate, its greatest liability. The manufacturer keeps more closely in touch with his operating force and increases its efficiency and its stability. The individual who himself elects to pay for such a service protects himself from the financial disaster of illness and of physical inefficiency, and really takes out *life* insurance as distinguished from "death" insurance. The employer and employee meet on a common ground of mutual interest, just as the insurance company and the policyholder join in mutual protection by following these life-lengthening methods.

Government investigation covering one million workers shows an annual average loss for the whole country of about 270 million days on account of illness. This does not by any means reveal the degree of physical impairment. There are millions of people who do not lose a day's work on account of illness, but who work year after year physically below par—billions of days of inefficient or sub-standard work that have never been counted.

The opportunity, the need, require no further demonstration. For a mathematical expression of results we must await further accumulation of data, but that is no reason why the work should be neglected and precious time wasted. There are so many things that can easily be done, even though the complete health service advocated by the institute is not considered feasible. The constant reminder to policyholders that a yearly examination and a consideration of their personal hygiene would be greatly to their personal interest, to the interest of their families, their business and their country, would help to gain recognition for this principle and stimulate many to follow it.

The National Association for the Study and Prevention of Tuberculosis has joined with the institute in urging upon the public through various channels—health departments, medical societies and others—that December 6 be fixed as Medical Examination Day, when all people, especially those believing themselves in good health, will either be examined or definitely arrange to be examined; in other words, take themselves to a "service station," whether family doctor or life insurance company or Life Extension Institute, and be thoroughly overhauled and started right for the coming year, repeating this yearly.

Can any one doubt the tremendous influence on national vitality, on physical preparedness for war or peace, of so general a practise? It is, of course, of immense importance that the work be standardized and that the public be educated in personal hygiene in addition to

securing such actual medical treatment as may be required at the hands of family physicians or specialists, and hence the need for specialization and organization in assembling available scientific knowledge and delivering it to the people.

Standardization of Method and Technique

Physical examinations are now being made for many purposes, for insurance, for employment, for military and athletic purposes, and in connection with school inspections. There is no reason why all such examinations should not be conducted along standardized lines, regardless of the object of the examination. If conducted and controlled by scientific men, they owe an obligation to science to make the results available in complete form for scientific study; and especially in connection with such a public service institution as life insurance, it seems incumbent as a public responsibility to make such examinations the instrument of scientific research as well as of mere business routine.

The examinations for life insurance as now conducted simply fulfil their primary object of keeping the mortality of the companies well within the American Experience Table; but if a larger and broader function can be exercised, which carries a benefit to the policyholder, reduces the mortality of the company without denying the benefits of standard insurance to any larger number of individuals, puts in motion a powerful force for social betterment, for improving the stamina of the race and insuring the dominance of our civilization, while furnishing almost priceless information to science, we may well ask, why hesitate? Why give the glory of the work to the next generation?

This brings me to the consideration of a new plan by which the insurance companies can utilize a by-product now going to waste, a plan that is free from any of the alleged objections that have restrained many companies from giving their policyholders the periodic health survey.

Nearly five millions of dollars are now annually expended among about 80,000 medical examiners for the purpose of ascertaining the physical condition of about 1,000,000 applicants for insurance. This work, as I have stated, is directed solely with a view to the business end of separating the insurable from the uninsurable.

It needs but a moment's clear thought, however, to grasp the fact that this vast machinery can be used for life-saving purposes, with little added expense, and that those who enter a life-insurance company may be the recipients of a large degree of personal protection as well as securing protection for their families after they are dead.

Real Life Insurance for Entering Policyholders

Our new plan involves a review of the application and medical papers for the purpose of preparing a message of guidance to the entering

policyholder, so that he may know exactly his condition as a risk and what he can do to improve it.

Even life-insurance experts are accustomed loosely to separate risks into two classes, standard and sub-standard. But we must admit upon reflection that these so-called standard risks vary within wide limits, not only individually but as to groups and types. Assuming the general mortality of a company to be 100, risks are accepted as standard whose condition warrants their classification in groups ranging from 50 per cent. of this table to 185 per cent., the average of 100 being made by the variation between these extremes.

This is no mere hypothesis. The recent medico-actuarial investigation showed that risks of certain classes, those indulging regularly, but in so-called moderation, in alcohol, for example, as well as overweights, have shown a mortality reaching up to 185, the most temperate individuals, of course, carrying their more self-indulgent fellows.

Now, companies try to exclude those whose mortality will probably exceed 125 per cent. of their table, but there are yearly accepted thousands of people who are far below their maximum possible condition of health, people who are in a high mortality class, or at least in a borderline class.

We contend that they are entitled to know this, to receive a message from their company, warning them of the trend of the mortality of their class and pointing the way to neutralizing it. Family history, overweight, lightweight, poor development, constipation, eye-strain, personal history of various disabilities and disease, none of which disqualify for life insurance, but all of which warrant some guidance as to how to live and often even as to medical treatment, point the way to a tremendous public service that can be performed by a business that is so interwoven with our social fabric that it has ceased to be a mere commercial organism.

I believe it to be a fact that the issuance of a life insurance policy has put the seal on many a man's physical failure. It is not only those who become ill and die who physically fail, but those who go on year after year, working below par, failing of achievement, failing to do their best work because of physical handicaps, often developed and confirmed by faulty living habits or bodily neglect.

False Sense of Security Engendered by a Life Policy

Such men, receiving an insurance policy, slap themselves on the chest and say, "I am all right; I guess I can stand another twenty years of high living," and, feeling that their families are protected if they should happen to make a mistake, they are confirmed in their *laissez faire* philosophy. To tell such men that they are 50 points distant from the well set-up, careful, temperate liver will perhaps rouse

latent common sense and manhood power to assert itself, and totally change the physical and mental type.

We are so wedded to evolutionary theories that we fail to recognize the extreme plasticity of the human mind and body and its susceptibility to modification by training and environment. There are sources of mental and physical power that too often go untapped. I have seen a tub of a man almost transformed into a greyhound type, keen and alert instead of heavy-footed and sluggish.

This service to entering policyholders can be based even upon existing medical reports, but it could, of course, be greatly increased in value by modifying the present form to include more thorough inquiry into living habits and a more thorough and complete report on bodily condition. This need not involve a more rigid system of selection, but would certainly bring about a more exact method of selection in the light of more complete knowledge of the condition of risks.

In furtherance of these ideas, the institute has formulated the plan for such a service, to include the mailing to the policyholder of the monthly Health Letters of the Institute, a review of the papers and a message to be prepared by the institute, and the policyholder to be urged to adopt the system of yearly examination.

Two companies already taking the periodic service, the Germania Life of New York and the Postal Life of New York, have subscribed for this service, and others are giving serious consideration to it.

Wide-spread Impairment among Our People

Wherever these physical examinations are made, they reveal a condition of practically universal impairment, not only with regard to minor impairments to which all civilized men and women are subject, but they show a certain degree of damage to the body from various causes which should be a matter of grave concern to those who are considering the available resources of our population to defend the liberties of our country or properly to utilize them in developing a civilization that shall endure and that shall be characterized by an improvement rather than a deterioration in the average physical, mental and moral type.

Studies of the trend of mortality in this country are not reassuring, and the recent results of the examination of recruits, long since foreshadowed by the quality of the material presented to the government in former years, only confirm what is found in the examinations of the institute, a sub-standard condition of physical insufficiency, characterized by manifold forms of defect, especially unsuspected chronic infection, mostly foci in the head, such as mouth and tonsillar infection, which make for organic disease and premature senility.

The increase in these organic affections and the apparent increased death-rate at the later age periods in this country have been repeatedly

ascribed to the saving of young life from communicable disease. Such a factor has not yet had time to exert such an influence, although it may well do so in the future and is an added reason for putting in motion neutralizing influences.

It should be remembered, however, that in Sweden and in England and Wales, where there has been a similar saving of young lives in the last thirty years, the death-rate at every age period has been lowered and the expectation of life at every age period has been increased.

Fundamental Basis of Preparedness

No campaign for preparedness will be complete that does not plan for a thorough periodic physical survey of the whole population and an intelligent application of scientific measures to the correction of physical defects and faulty living habits, as well as a further study of the factors that make for degeneration and the possible ways for neutralizing them.

The opportunity open to life-insurance companies to cooperate in the work of building up national vitality may be summarized as follows:

1. Educational work among policyholders by means of health bulletins.
2. Direct intensive work among policyholders by means of periodic health surveys solely for the purpose of prolonging life.
3. Reports and advice to entering policyholders with regard to their condition as risks and the ways by which they could become better risks.
4. Cooperation with health departments and health agencies to secure better health legislation.
5. Standardization of method and technique in the system of medical examinations, in order that the results may be of greater value to science in the study of human defects and the influence of living habits.
6. The stimulation among medical men throughout the country of a close study of diagnostic technique in the detection of early signs of bodily impairment and the personal hygiene appropriate to combat such tendencies.

Practically all of these things are now being done to some degree, but there is need for more concerted action for a complete utilization of these facilities instead of a partial and experimental use.

General Conclusions

During the last fifty years there has been a rapid accumulation of scientific knowledge, and so marvelous an adaptation of that knowledge to the modification and development of civilization so far as it relates to the complexities of living and of social and industrial organization, that we have been lulled into a sense of self-confidence and security as regards our racial progress. It is too frequently assumed that this mere accumulation of knowledge and of the conveniences and ingenious devices of civilization reflects an actual improvement in the racial type.

I do not think we have any evidence that man as an organism, whether in regard to his physical or mental capacities, now presents a higher average type than characterized the nations of antiquity. Indeed, so far as his physical structure is concerned, there is much evidence to the contrary, and I think we may be assured that the great minds of antiquity would have made equally good use of present-day knowledge if they were with us to-day and in a position to utilize it.

Before the advent of the recent war, foreign countries, as I have stated, showed a decided improvement in vitality at every age period of life, offering some encouragement to the belief that, notwithstanding the tendency of complex civilization to place the organism out of adjustment with natural conditions, there were, nevertheless, balancing factors determining an advancing rather than a receding tendency with regard to physical stamina and adjustment to the changed conditions of civilized life.

What effect the great war will have upon those countries that have been depleted of their best types remains to be seen. Grave concern is surely justified as to the outcome.

I have referred to the mortality trend in our own country and its rather sinister significance. Whatever may be the factors at work, whether over-dentistried teeth, admixture of foreign blood, or the strain of a remarkable industrial expansion with its disturbance of social equilibrium, surely there can be no question with regard to the urgent need for completely determining the condition of our population and putting into motion such agencies as we can command favorably to govern the physical trend of the race.

It is true that the possible ultimate influence of saving the unfit must be reckoned with, as Huxley long ago pointed out. We should, however, bear in mind that few people are in an ideal sense absolutely fit. We have all grades of impairment, and in the full utilization of our increased knowledge we not only save the unfit but improve those of alleged fitness, affected with the lesser degrees of impairment.

This work of improving present existing stock has, of course, its limitations. It is one of immediate, urgent need, in order that our country may be strengthened for the work of the next quarter-century; but, taking a long-distance view, we must recognize the imperative need of setting in motion rational eugenic as well as authenic methods of safeguarding our future.

At least the gross contamination of the stream of germ plasm can be prevented by elementary precautions with regard to the mating of the grossly unfit. Neglect to do this effectively is so stupid a concession to medieval tradition that we may confidently expect that effective action along these lines will soon be more uniform throughout the country.

When we consider the amount of energy and money and time and human intelligence that has been exerted to provide the superficial appurtenances of civilization; how we have girdled the earth with wireless telegraphy and the telephone; our undersea and overhead activities; and all the marvelous developments that science has provided for amusement, for dissipation, for money-getting, for warfare, for destroying human life—it is rather pitiful to think of our helpless condition as we face the average man of to-day and his physical equipment.

The condition of the average individual as a structure is a lamentable contrast, for example, to the magnificent condition of this skyscraper in which we are holding this meeting—the one perfect in all its details, a splendid monument to human business and artistic genius; the other a reproach upon our civilization in its condition of physical inadequacy, of infection, of faulty development, of maladjustment to environment.

If this maladjustment were necessary, it would be well to make the best of it and not talk so much about it; but, fortunately, it is to a very large degree preventable and positively not to be accepted as necessary.

This picture I have drawn of the bodily condition of the civilized American may not be impressively optimistic, but it happens to be true; and this is a time when, with optimism as our background, we must place the bald facts in the foreground if we are to have effective action directed to safeguarding our country. With the leading nations of the world in a death grapple we can not stand idly by as children viewing a tragic film play, and trust to luck for everything to come out right. Action is needed. The insurance companies can mobilize for physical preparedness among the people. Will they do it?

LIFE INSURANCE AND THE WAR

By Professor S. S. HUEBNER

UNIVERSITY OF PENNSYLVANIA

LIFE insurance serves two great purposes—protecting the home against the untimely loss of the income-producer, and inculcating the spirit of thrift by rendering easy and systematic the saving of small sums over a long period of time into a substantial amount for protection against dependency in time of need or old age. War, on the contrary, is instrumental not only in destroying many breadwinners in the prime of life, but, by wasting and depreciating the savings referred to, hampers and weakens the great institution of life insurance in the proper fulfillment of its noble mission.

In discussing the effects of the present war upon life insurance, only passing mention need be made of American companies. Business in the United States is to-day admittedly on a war basis, and what has

proved to be a source of misfortune to other leading nations in a business way has been the cause of unprecedented prosperity for us. This prosperity, with its great increase of employment and wages, its enlargement of production, and its abundance of credit at remarkably low rates, has been reflected favorably in the record of American life-insurance companies. The volume of business in the regular companies increased during the year 1915 by over $1,250,000,000; the payment for surrendered policies shows only a normal increase; while loans on policies were the smallest since 1909, the increase amounting to only about one half that recorded for the years 1914 and 1913. Considerable interest has also been manifested concerning the effect of the war on the policies of various American companies issued in Europe prior to the beginning of hostilities, and at the ordinary rates of premium. Yet, judging from Mr. John S. Thompson's excellent paper on "The Recent European War Experience of the Mutual Life Insurance Company of New York,"[1] the mortality under such policies has been but little in excess of the mortality experience during peace times and amounts to but a trifle of the total claims paid on all domestic and foreign business combined. During approximately the first year of hostilities the war losses of the Mutual Life Insurance Company amounted to but .196 per cent. of the $202,990,000 of business in force on July 1, 1914, in the belligerent nations of Great Britain and her colonies, France, Belgium, Italy, Germany and Austro-Hungary.

In discussing the immediate effects of the present deadly conflict upon life insurance, we are concerned primarily with the situation as it presents itself in the leading belligerent nations. When invited to discuss this subject, I was reluctant to accept because of the limited and fragmentary character of the information at hand, and also because the extremely deadly nature of the present war makes the use of records established in previous wars dangerous, if not useless for purposes of comparison. In view of these circumstances, the thoughts presented in this paper are not meant to be final in any sense. They can not be. They are tentative suggestions relating to present and future problems growing out of the war, and are offered with the hope that they may be kept in mind for detailed study when the war is ended and full facts shall be available. For purposes of convenience, this paper is presented under four main headings, (1) the financial effects of the war as exhibited by depreciation in security values, increased taxation, increased lapses and policy loans, and decreased volume of new business; (2) the extent and effect of war claims, and the mortality among civilians in the belligerent nations; (3) the use of policy restrictions upon military and naval service; and (4) the after-war effects on those who serve in the armies.

[1] *Transactions of the Actuarial Society of America*, Vol. XVI., Part II., pp. 297–314.

Financial Effects of the War

Probably the most serious immediate effect of the war upon life offices abroad was the depreciation in the value of their securities, occasioned chiefly by the fact that new high interest-bearing government bond issues set up a new standard of interest rates which operated adversely to existing low interest-bearing bond issues held by the companies. Since all the belligerent governments have been obliged to bid for funds at greatly increased rates, it may be assumed that the problem of depreciation in security values is common to all the belligerent countries of Europe. Unfortunately, it is not possible to estimate this depreciation even in England. Many offices revalue their assets only every five years, thus making it difficult to separate the effect of depreciation prior to the war from that occurring subsequently. Most of the official returns, moreover, supply no detailed information concerning the securities owned, as is done in the United States and Canada; and there is, furthermore, a lack of uniformity in the basis of valuation adopted for different types of securities.

The importance of this depreciation from the standpoint of English offices is exemplified by the facts presented for the Prudential Assurance Company (with total assets of £94,777,842 at the close of 1915) at its last annual meeting by Mr. Thomas C. Dewey, the chairman of directors. According to his statement:

> The issue of a 4½ per cent. war loan in July, 1915, followed by the sale of 5 per cent. Exchequer bonds, altered the whole standard of interest rates. The result was a further depreciation in the market value of all interest-bearing securities, and, although this depreciation has to some extent been disguised by the retention on the Stock Exchange of minimum prices, yet it would be idle to ignore its existence.

Accordingly, he explains, since the beginning of hostilities the company has adopted the policy of "carrying substantial amounts of investment reserve funds rather than further writing down the value of its securities." To the beginning of March, 1916, £2,600,000 was thus added to the investment reserve fund. In addition £700,000 was carried to a special contingency fund in the Ordinary Branch to meet any emergency which might arise. In all £4,100,000 was added to reserve funds of various kinds to meet the special conditions imposed by the war. And it should be remembered that during the six years preceding the war, this large and representative company wrote down its securities by over £5,000,000.

In viewing the above situation, however, a hopeful view of the future is still taken, because life-insurance companies are seldom obliged to sell securities since their premium and interest income nearly always exceeds the current requirements for claims and expenses, because loans of various kinds are constantly being paid off, thus furnishing a constant supply of funds for fresh investments yielding a higher rate of interest, and because of confidence in the ultimate recovery of the securities which

have been written down, it is believed, only temporarily. To again quote Mr. Dewey:

> So long as the interest is duly paid, so long as we have good reason to believe the capital will be paid, and so long as we do not have to realize, we maintain that such securities are quite as valuable assets of the company as they were at the date of purchase.

Some British offices, it may be stated, have partially compensated for the depreciation in their assets by adopting a higher future rate of interest for valuing their liabilities than had been used at the previous valuation, while others have, owing to the serious inroads into surpluses, reduced or omitted entirely their rates of dividend or bonus distribution.

Against the loss from depreciation, the only direct gain is the increase in interest that is being realized, and the likelihood that interest rates are apt to continue high for some time to come. But this factor is counteracted by the great increase in the income tax for what is likely to be a long period. In the United Kingdom the tax has now reached 5s. in the £ for life offices, and is assessed upon their interest from investments, after deducting the expenses of management, and not upon profits. The extent of the burden is indicated by Mr. Dewey for the Prudential Assurance Company when he stated at the last annual meeting:

> The war has had the effect of decreasing all three main sources of profit—favorable mortality, interest earned in excess of the rate assumed in the valuation, and saving in expenses. . . . The rate of interest earned in 1915, after deduction of income tax, was £3 19s. 6d., as against £4 3s. 10d. in 1914. The reduction is almost entirely due to the increased income tax to which we have been subjected.

Another very noticeable result of the war has been the heavy investment by life offices in all the belligerent countries in war loans. Not only have the new funds of the companies, accumulated from day to day, been invested in this manner, but also a substantial part of their old funds which had previously been invested in American and other securities and which could be liquidated abroad and reinvested at home to greater advantage in high interest-bearing war bonds. The total extent of such investments can not yet be ascertained, owing to the absence of official reports. But that the movement has reached large proportions in all the leading belligerent nations is beyond question.[2] It has been stated, for example, that life insurance organizations in Germany with assets of $750,000,000 in 1913, had, by the beginning of 1916, subscribed $120,000,000 to the German war loans. An analysis of the annual reports of six important British offices shows that their holdings

[2] Mr. S. G. Warner, president of the Institute of Actuaries, at a meeting of the institute in London, November 27, 1916, estimated that "since the beginning of the war British life offices have invested in British government securities of various kinds upwards of £75,000,000. They have sold or lent to the Treasury, under its schemes *A* and *B*, securities of the face value of over £46,000,000."

of British government securities increased between December 31, 1914, and December 31, 1915, from £1,618,599 to £16,049,727, an increase of 892 per cent. At the close of 1914 the total assets of these six companies amounted to £119,941,781 and British government securities represented only 1.3 per cent. By the close of 1915 the total assets of these companies aggregated £124,396,876 and the holdings of British government securities (£16,049,727) had risen to 12.9 per cent. If this showing averages approximately the same for all the offices in the United Kingdom, life insurance has truly proved a great financial aid to the prosecution of the war. One of the six companies referred to, with total assets of £6,503,916, increased its holdings of British government securities during 1915 by 1,548 per cent., and the same amounted to 17.5 per cent. of its total assets. The Prudential's holdings amounted to £13,247,432, or 18.6 per cent. of the total assets assigned to its industrial department plus 9.8 per cent. of the assets assigned to its ordinary department. At the close of 1914 the two percentages stood, respectively, at only 2.9 per cent. and .3 per cent. As a matter of further interest it may be stated that during the year the Prudential took advantage of the fluctuating rates of exchange and sold to neutral countries £1,200,000 of their own securities, this action, in the words of its chairman, "being not only of advantage to the company, but of assistance to national interests, as it brought back capital from abroad for investment in our own country." Of course, all published accounts manifest the utmost confidence in these prodigious investments in government securities, since the investment rate is high and the safety of the principal assumed to be unquestioned. Let us hope, for the sake of life insurance in all the belligerent nations, that the prolongation of the war and the continued drain upon national resources will not be such as to prove this confidence to have been misplaced.

At the outbreak of the war widespread fear was entertained that unemployment on a large scale would lead to a great number of lapses. In fact, legislation relating to industrial policies was enacted in England (The Courts (Emergency Powers) Act) to the effect that certain classes of industrial policyholders might, during an indefinite period, suspend the payment of premiums and at the same time retain the benefit of their insurance. This emergency legislation was enacted in the expectation that large classes of the industrial population would, as a result of the war, find their occupations gone or their incomes greatly reduced. Such fears, however, proved entirely unfounded, since in England the working classes, owing to the industrial demands of the war, have enjoyed constant work at high rates of pay. I am also advised that in Germany the situation is not nearly so bad as originally expected, that the premium income of the companies has been quite regular, and that the lapse ratio has not been unusual. In all probability some importance should be attached to the mental effect which the

great world calamity has had upon the careless in influencing them to continue their policies in the interest of preparedness against death.

Detailed information concerning the lapse ratio is again obtainable only for English companies. In the case of 35 British offices[3] the total amount paid by the companies during 1915 was only £2,166,000, against £2,247,000 in 1914 (a decrease of over 3 per cent.) and against £1,955,-700 in 1910, an increase of only 10.7 per cent. The 1916 ratio to life and annuity funds was only 0.6 per cent. as compared with 0.7 per cent. for the years 1914 and 1910 and an average of about 2.3 per cent. for American companies. In the industrial business of these companies the sum paid during 1915 was less than in 1914 by over 15 per cent.

Another fear at the outbreak of hostilities was the likelihood of policyholders resorting to a wholesale utilization of the borrowing capacity of their policies. In anticipation of this contingency and to forestall the expected rush, many British offices announced higher rates of interest for new loans, and in some cases rates on existing loans were also increased. But, as in the case of surrenders, this misgiving was entirely unwarranted, and for the same reasons. For 28 British offices[4] the amount of policy loans outstanding at the end of 1915 showed a slight decrease as compared with the close of 1914, the ratio to life and annuity funds decreasing from 7.7 to 7.6 per cent. These ratios are but slightly higher than the 7.2 per cent. recorded in 1910–11, and compare very favorably with the ratio prevailing in the United States. In Continental Europe, judging from the limited data at hand, the situation was not so favorable. My information is to the effect that in Germany, at the outbreak of the war, the procurement of money to meet the big demand for policy loans constituted a real problem and that for this purpose a "Bank of German Life Insurance Companies" was created which loaned money on securities.

But while, in view of the circumstances, the lapse and policy loan ratios did not prove unfavorable, this can not be said concerning the volume of new business written. This is as might be expected, owing to the call to the colors of some millions of fit men who otherwise would have constituted a fertile field for new insurance; to the inability of the companies to undertake the war risk without charging almost prohibitive premiums; and to the absorption into the ranks of the army of a large proportion of the companies' agency forces. To some extent, too, the poor dividend results shown since the outbreak of the war may possibly have proved an adverse factor. According to English insurance journals, French life offices are generally reporting greatly reduced new business returns, partly because the enemy is in possession of the great industrial districts of the north and partly because the majority of the district managers and agents of the companies have been called

[3] For detailed summary see the *Economist*, September 16, 1916.

[4] For detailed summary see the *Economist*, September 2, 1916.

to the colors. The last factor must also be an important one in Germany. In England the volume of new business for the year 1915, written by 14 companies[5] within the United Kingdom, shows a decline of 8.5 per cent. as compared with the preceding year. Seven of these companies wrote business outside of the United Kingdom, and the volume of such business shows a decline of 37.5 per cent. Our list includes two industrial companies—The Prudential and Refuge—and it is interesting to note that, despite the difficulties enumerated, their new ordinary business for 1915 exceeded that of 1914 by over 5 per cent., while their industrial business remained practically the same. If, however, the industrial business be omitted, the total new ordinary business of the 14 offices referred to shows a reduction of approximately 20 per cent. as compared with 1914.

Extent of War Claims

But while the financial effects of the war in their relation to life insurance have been serious, our thoughts naturally turn to the extent of war claims paid. The deadly nature of the present war is indicated by the data relating to deaths reported up to July 31, 1915 (and covering over 11 months of actual hostilities) among 11,819 officers serving in British regiments of the regular army at the commencement of hostilities, which was submitted by Mr. D. H. Gordon-Smith to the Insurance Institute of Yorkshire. In the infantry branch the loss ratio reached the unusual figure of 18.3 per cent.; in all the combatant branches it reached 13.2 per cent.; while for all services it averaged 11.9 per cent. These figures contrast unfavorably with the rate of mortality in the British army during the South African War of only 5.3 per cent. per annum among officers and 3.8 per cent. among non-commissioned officers and men.[6] Mr. Gordon-Smith's figures, however, do not include officers missing or unofficially reported killed or dead, and many of these probably were numbered later among the dead. In his excellent paper on "The European War Risk with Particular Reference to the Practise and Experience of Canadian Companies," Mr. Arthur B. Wood concludes, although obliged to make many assumptions in reaching his conclusions, that the death rate during the first 11 months of hostilities for officers among the first division of Canada's expeditionary forces was 16.0 per cent., for other ranks 11.4 per cent., and for all combined 11.5 per cent.[7] These figures are indeed impressive, especially when it is borne in mind that the deadliest campaigning of the war probably occurred subsequent to the period referred to.

[5] For detailed statement see the *Economist*, July 8, 1916.

[6] This data is summarized in Arthur B. Wood's paper on "The European War Risk with Particular Reference to the Practise and Experience of Canadian Companies," *Transactions of the Actuarial Society of America*, Vol. XVII., Part I., p. 57.

[7] Wood, p. 59.

Since permits for military and naval service were not generally required under policies issued by English and Canadian companies prior to August, 1914, it is most difficult to ascertain even approximately the amount of insurance at risk on the lives of those who enlisted. While the rate of war mortality based upon insurance exposure is an all-important subject for study, no conclusive data along this line has yet become available. Various statements, however, showing the effect of war claims upon mortality as a whole have been made. Mr. Wood presents an interesting table showing "the percentages which the net death losses (sums issued less reserve thereon) during the year ending December 31, 1915, were of the expected by the $O^{m(5)}$ Table" for eight Canadian companies. Summarizing his table, Mr. Wood concludes that:

> The total mortality including war claims is seen to have been remarkably favorable in every instance, the ratio of actual to expected ranging from 42.6 per cent. to 72.9 per cent., while for the eight companies combined it was 58.4 per cent. The net loss on the war claims for the combined companies was 13.3 per cent. of the expected claims. The gross war claims for nine companies combined were .134 per cent. of the mean Canadian business in force. . . . The gross Canadian claims incurred by the 9 companies were $5,834,822, of which $900,869, or 15.2 per cent., were due to the war. The war claims reported by the Canadian companies include deaths from all causes among combatants and also deaths among non-combatants through acts of war, such as the sinking of the *Lusitania* and other vessels.[8]

Some idea of what war claims have cost the English companies may be obtained from the instructive table published by the *Economist* under date of August 12, 1916, giving the war mortality claims for 52 British companies for the years 1914 and 1915. It should be noted, however, that in the case of 7 companies the last year covered by the report ends somewhere within 1915, while in six instances the last year reported runs into 1916. Total war claims paid by the above offices for the first 17 months of the war amounted to £4,313,300. In 1915 such claims totaled £3,042,500, or 11.6 per cent. of the total death claims. In 1914 war claims totaled £1,270,800, or 5.5 per cent. of the aggregate claims for the year, and 13.2 per cent. when based on the five months' duration of the war during that year.

A further analysis of the table shows that the experience of different companies varies considerably. In 6 instances war claims amount to 5 per cent. or less of the total death claims; in 16 cases over 5 per cent. and less than 10 per cent.; in 14 over 10 per cent. and less than 15 per cent.; in 6 between 15 per cent. and 20 per cent.; in 6 between 20 and 25 per cent.; and in 4 over 25 per cent. Of the last four companies, three experienced, respectively, the very high ratios of 28.3 per cent., 34.8 per cent. and 44.6 per cent. But with these relatively few exceptions it may be said that English companies have not thus far found war risks a greater burden than anticipated, and up to the end of 1915 few companies are said to have reported a mortality in excess of that pro-

[8] Wood, pp. 55–56.

vided for under the standard table in use. Moreover, new policies issued to soldiers and sailors have carried heavy additional premiums, and the companies have, as a consequence, had the benefit of considerable extra revenue in respect to the war risk assumed. Regular life-insurance companies have also been affected less than might be expected because the great majority of those on the firing line are young men who either carry no insurance at all or who, when insured under regular policies, carry, on the average, only a moderate amount of protection. The war losses paid, however, by English companies have reached such proportions that all published accounts seem to recognize the seriousness of the decision by the companies at the commencement of hostilities to charge no extra premium to existing policyholders who should enlist in active military or naval service.

Since by far the largest number of men at the front belong to the classes normally covered under so-called industrial policies, it follows that the industrial companies in England have had to pay a very large number of claims. But here the redeeming feature from the standpoint of the companies is that the average individual payment is small, only about £18. By April, 1916, 7 English industrial companies had reported 61,005 war claims aggregating a total of £1,135,046. Of these, one company—the Prudential—paid 38,479 claims aggregating £830,-614. For the year 1915 the war claims of this huge company, whose policyholders are representative of the whole of the United Kingdom, constituted 11.4 per cent. of the total death claims. This percentage should be compared with Mr. Wood's estimate of 11.5 per cent. as the combined death rate for all ranks in the first division of Canada's expeditionary forces during the first eleven months of hostilities, and with 11.6 per cent. representing the combined ratio of war claims to total claims during 1915 for all the 52 companies already referred to.

Little direct information is at hand to indicate the war claim experience of life-insurance companies in Germany, France and Austro-Hungary. In these countries, however, the companies have generally seen fit in the past to protect themselves by incorporating a war clause in all their contracts to the effect that, unless an extra premium is paid for a permit to engage in naval or military service, the company will pay only the reserve value on policies in case of death during the period of such service. The war risk of these companies is thus greatly minimized. Again, the war risk is confined largely to the younger men, many of whom are not insured at all with companies, and who, as a class, only infrequently carry large policies. The older men, who are naturally the most heavily insured, are not exposed to the hazard of the younger men on the firing line, since they are, although in the active service of the army, engaged in policing railroads and towns, looking after the shipment of rations and munitions and in similar less hazardous duties; and the mortality among them is probably not far different from that pre-

vailing in normal times. Moreover, the four scourges of past wars—typhoid, typhus, cholera and lockjaw—have, according to medical experts recently returned from the front, been practically wiped out in the French and German armies. Evidence, gathered through correspondence and interviews with those familiar with the situation, also shows that the mortality among the civilian population of Germany, despite an increased death rate from industrial accidents attributable to the speeding up of war industries, and the wholesale rearrangement of the working personnel, has been considerably lower than the average during years of peace, a situation probably traceable to a more restricted diet, more efficient and universal care, reduced use of alcoholic beverages, and much more constant and compulsory physical exercise.

Considerations like the foregoing have led to an experience on the part of Continental European offices much more favorable than was expected at the beginning of the war. According to advices obtained through correspondence, the death rate of policyholders in German companies was considerably higher during 1914 than in the year preceding the war, although not equal to the tabular expected mortality; while during 1915 the actual mortality to the tabular mortality expected was lower than in 1914. The 50th annual report of the Prussian Life Insurance Company,[9] one of the leading German life offices, is of interest in this respect since it covers seventeen months of actual hostilities. At the outset of the war this company is reported to have had nearly 66,000 policies outstanding (representing $74,330,000 of insurance) and the vast majority of these policies, we are informed, were on the lives of men within the age limit for military service, the company thus having a very considerable exposure to the war hazard. The average policy for all insurance was, according to the report, about $1,200, but the average loss per person in military service is reported at only $577, due mainly to the smaller than average amount of insurance carried by the younger men. Notice should be taken of the fact that the maximum amount of insurance carried by this company on any one life is about $6,250. During the first seventeen months of war, eight war claims resulted for each 1,000 lives insured. In 1914 the claims incurred from war ($118,512) amount to 11.6 per cent. of the total claims paid, while the total mortality from all causes, including that incurred from war, equalled 110.6 per cent. of the year's tabular expected mortality. In 1915 the war claims (185,630) represented 16.3 per cent. of the total claims paid, while the total mortality from all causes, including war, amounted to 105 per cent. of the tabular mortality for the year. In all probability the extra charges for, or policy restrictions concerning, the war risk left the company largely unaffected by the increased mortality from war, since we are informed that the company was enabled to continue its long-established dividend of 16 per cent. per annum to its

[9] Summarized in the *Economic World* for July 22, 1916, p. 115.

stockholders, to give to its participating policyholders an amount equal to the distribution of previous years, to set aside a special reserve to meet war claims in 1916, and still to show a surplus of almost $2,000,000 as compared with reserves of about $20,000,000.

Policy Restrictions relating to Military and Naval Service

Space limits make impossible more than a brief outline of the methods adopted by the companies of a few of the leading belligerents in assuming the war risk. Detailed information is at hand as regards the methods adopted at present in Canada, England and France. Concerning Germany, however, the available information as to what is done at present is so scanty as to make any detailed statement impossible. It may be stated at the outset that, at the commencement of hostilities, Canadian and English companies voluntarily waived all war restrictions in policies previously issued, and assumed the war risk without any extra premium charge. On new business, however, restrictions were imposed and an extra premium demanded. The following résumé merely presents the main outlines, so as to show the principal points of similarity and difference:

1. In Canada[10] the companies follow the general plan of permitting service in the militia within Canada, but require notice in case of foreign service. Most of the companies require such annual extra premiums as they may fix; some provide that the premium shall not exceed 15 per cent. per annum of the sum insured; while one company, at least, charges a single extra premium, grading the same according to the amount of insurance, and agreeing to refund, at the close of the war, such portion of the extra premium as the company shall determine in view of its experience. On failure to comply with the terms of the war clause, some companies provide for the return of all premiums paid, with 5 per cent. compound interest if death should occur during service or within a stipulated period thereafter; others return the legal reserve; others agree to pay 25 per cent. of the face of the policy; and at least one company declares the policy to be null and void. A few companies refuse altogether applicants who have enlisted in foreign service or intend to do so. According to Mr. A. B. Wood:

> The extra premiums charged range from 7½ to 15 per cent. per annum of the sum insured.

2. In England[11] the conditions under which the war risk is assumed vary greatly and many companies are declining the risk entirely. When the risk is assumed and the insured engages in war service abroad, without having paid the extra premium, some companies limit the sum payable at death to double the premiums paid during the war and a stipu-

[10] Arthur B. Wood, "The European War Risk with Particular Reference to the Practise and Experience of Canadian Companies," *Transactions of the Actuarial Society of America*, Vol. XVII., Part I., pp. 49–54.

[11] For a fuller account see the *Insurance Record* (London), September 15, 1916, pp. 434–435.

lated number of months thereafter; others return only the premiums paid; and others reduce the sum insured to 10 per cent. (or some other stipulated percentage) during the first year of service, increasing the amount by 10 per cent. (or some other designated percentage) for each succeeding year of service up to the full sum insured. At the termination of the war, the companies usually provide that the policy shall be reinstated to the full sum insured, if satisfactory evidence of health is furnished. If the evidence is not satisfactory, some companies return all the premiums paid; others increase the insurance yearly, according to some plan, up to the full amount; while others call for no evidence of health and will reinstate the policy to its full amount. According to the *Insurance Record,* under date of September 15, 1916, the extra premium at the beginning of hostilities was generally seven guineas per cent. annually; while "subsequently ten, then fifteen guineas were quoted, and to-day the standard rate is nearer twenty guineas." Moreover, we are informed that the offices usually limit their risk to £1,000 or less.

3. French policies, it is stated,[12] usually contain the following military and naval service clause:

> The policy shall not be forfeited if the extra premium is not paid; but if the assured die within eight months of the cessation of hostilities, the company will pay to the beneficiaries only the reserve instead of the full face value of the policy.

The eight months' limitation, we are informed, has been reduced to three months at the suggestion of the government. According to the *Post Magazine and Insurance Monitor,* under date of May 27, 1916,

> An extra premium of 10 per cent. of the sum assured has been paid by soldiers and reservists of regiments of the line; 7½ per cent. by territorials and their reserves; and 5 per cent. by the non-combatant branches of the army. Originally, these extras were intended to cover one year only, but upon the request of the government the companies agreed to make no additional charge for the second year.

According to the same journal under date of August 19, 1916, the companies decided at the beginning of the third year of war not to ask for a new extra premium. It should be added that the companies decided, at the request of the government, "to proportionately return to policyholders after the war sums received for war risk premiums over and above the total amount of claims caused by the war."[13]

After-war Effects on those who serve

In discussing the war risk, sight should not be lost of the after-war effects on the fifteen or twenty millions who have served in the present war. The importance of this subject can only be inferred at present and certainly will and should be the subject of careful study following the close of hostilities. Many who studied conditions at the front are ap-

[12] John S. Thompson, "Military Service and Its Bearing on the Policy Contract," *Transactions of the Actuarial Society of America,* Vol. XVI., Part II., p. 302.

[13] *Post Magazine and Insurance Monitor,* May 27, 1916, p. 393.

prehensive of the ultimate mortality results. My information is that a large proportion of those serving in the armies has been affected by heart and kidney ailments, trench nephritis, and venereal diseases, and that, judging from the past, these ailments affect the future vitality of the victims. Apprehension is also felt by many concerning the future vitality, especially from the standpoint of tuberculosis, of the three million or more prisoners of war. Badly treated from the standpoint of sanitation, living mostly in idleness, and subjected to an unaccustomed diet, a very large number, it is felt, will leave their prison camps as sub-standard lives.

In conclusion it may be said that the adverse financial and mortality effects of the war, as outlined in the preceding pages, have made serious inroads into the surpluses of practically all companies. What the future holds in store will necessarily depend upon the length of the war. Fortunately, the companies practically everywhere pursued a very conservative policy prior to the outbreak of hostilities. Premiums were computed on the basis of mortality tables which leave a large margin of safety, and on assumed interest rates equal to only about two thirds of the return actually realized in normal times. Had such conservatism not been practised there would in all probability have resulted a large number of failures, and the future would have been dismal indeed. As far as English companies are concerned, anxiety at present is limited chiefly to a consideration of how far dividend distributions to policyholders will be affected. Many have already reduced the same, and some have, as an act of caution, omitted a distribution altogether. Judging from numerous statements made, the hope seems quite general that the adverse financial and mortality results of the war thus far can be made good by the mortality gains of a few subsequent years.

For American companies the experience and practises of foreign companies in relation to the assumption of the war risk has an important bearing. The writer is convinced of the advisability of incorporating a war service clause in future American policies, the same to remain in force during at least the first ten years of the contract. Foreign experience during the present war seems to indicate that, under such a clause, the companies should be given latitude in charging such extra premiums as they may determine necessary. It is also felt that careful consideration should be given to the propositions: (1) of considering the extra premium feature as participating in character with a view to refunding any excess extra premium following the close of hostilities; and (2) of ascertaining the most equitable method of reinstating the policy upon the cessation of hostilities, should the insured, for causes arising from the war, be unable to produce satisfactory evidence of health. The desirability of a careful consideration of the relation which the government should bear equitably to the war risk is also suggested, since the burden to some extent, it is believed, should be borne by the community as a whole.

MYTH AND ERROR IN THE RISE OF NATURAL HISTORY

By S. E. LONGWELL
BROWN UNIVERSITY

NATURAL history is the raw material from which all the other biological sciences are made. As long as false notions made up a considerable part of conceptions regarding plant and animal life, rapid progress in those sciences was impossible. A survey of the "rubbish" in the rise of natural history explains, in some measure, why this progress is comparatively recent.

It is astonishing how long a myth or superstition, once it gets the popular ear, can live and thrive on mere repetition and, like Vergil's bird of Rumor, attain larger proportions as it goes. Darwin points out that in science false observations are far more serious than false theories. False notions must be discarded altogether before the foundations of a true theory can be laid. False theories, on the other hand, lead directly to true theories if the data on which they are based are true.

We are accustomed to think of mythology as emanating chiefly from Greece and Rome—a consequence of our over indulgence in classical studies. As far as ancient natural history is concerned we get more truth and less fiction from Grecian sources than from any other nation or from any other of the twenty centuries following that of Aristotle.

He, of course, is rightly regarded the father of natural history. While there is evidence that some valuable scientific work had been done previous to the fourth century, B.C., especially in medicine, yet to Aristotle must be given the credit of instituting the right method in advancing knowledge of natural phenomena. Notwithstanding the fact that he may have had some good authorities for reference, and the resources of Alexander's kingdom at his disposal in writing a natural history, yet his "Historia Animalia" is a remarkable achievement.

In reviewing a translation of a fragment of his work we note the following: That he classified sponges as animals and that he possessed accurate notions of the essential features and relations of mammals. He recognized ruminants by their four stomachs, the parts of which he describes in detail. He is more accurate in his knowledge of the circulation of the blood than most observers down to the time of Harvey. He treats of mollusks, crabs, etc., so as to leave no doubt that he had closely observed and studied them. He declared that the nature of animals and vegetables are similar. He had worked out a pretty accurate knowledge of bees and grasshoppers. He had observed the development of the chick embryo from three days on. His discussion of reproduction in fish—ova

and spermatozoa—and their relations accords with the teaching of modern biology.

Osborne says of him:

He distinguished five hundred species of mammals, birds and fishes, besides exhibiting an extensive knowledge of polyps, sponges, cuttle-fish and other marine forms of life. He understood adaptation of structure to function, distinguished between homogeneous tissues made up of like parts, and heterogeneous organs made up of unlike parts; he perceived the principle of physiological division of labor, unity of plan or type in certain classes of animals, and the forces of hereditary transmission.

For the most part Aristotle steered clear of mythical notions about animals that must have been generally believed by his contemporaries. His errors are many, but very pardonable when we consider his is the first real attempt to write a natural history. He speaks, for instance,

of flying reptiles; other reptiles move by four limbs.
In all animals the brain is without blood.
The mammalian heart has three cavities.
The lion has one bone in the neck, but no vertebræ.
There is a kind of ox which has a bone in its heart and there is also a bone in the heart of the horse.

He seemed to accept the general belief that the eyes of serpents and swallows, if pierced with a pointed instrument, would grow again.

If sheep drink of certain waters they will produce black lambs. And in Antandria there are two rivers, one of which turns the sheep white and the other black, and the Scamander appears to make the sheep yellow.

All insects survive being divided, so that wasps live after being cut asunder —only the head will not survive alone.

Eels, many insects, and some other animals spring from putrid matter; bugs from moisture, and some insects from the dew upon the grass.

He credits the story that the salamander puts out fire by walking over it. He says:

Honey falls from the air—no honey is produced before the rising of Pleiades.

He believed that the fertilization of the egg was often brought about from the breath of the male, for if the hen of the partridge stands in the way of the breath of the male she conceives.

He thought that certain fish produced ova under the influence of the stars, and that sheep and goats produce males or females according to the water they drink.

When the wind is high bees carry a stone with them for a balance.

The bones of animals depend upon one bone and are connected with each other like the "veins," and there is no such thing as a separate bone.

Besides Aristotle's no other work has come down to us from the Greeks that ranks as natural history.

The Roman empire likewise produced but one naturalist—Pliny. But Pliny does not rank with Aristotle. In the first place he attempted

to encompass all knowledge and must therefore have depended upon others for most of his information. And, though hating the Greeks, he acknowledges Aristotle his chief authority. The best of his work is Aristotle's, but it is mingled with more matter from other and less reliable sources.

The treatment of the elephant well illustrates the difference between the two. Aristotle's would take rank with that of an author of modern biology. But Pliny says the elephant has religious respect for the stars and veneration for sun and moon and that they purify themselves in the new moon. He speaks of a dull, domesticated elephant conning over his lessons in the night time. If an elephant meets a man lost in the desert he is merciful and points out the way.

Pliny credits other wonderful tales, such as the following:

Ethiopia produces horses with wings. A wild beast is found there characterized by a remarkably heavy head, being bent always toward the earth. Were it not for this it would prove the destruction of the human race, for all who behold its eyes fall dead upon the spot.

There is the same power also in the serpent called the basilisk—it destroys all shrubs by contact and by its breath; it burns up all grass and breaks the stones. To this dreadful monster the effluvium of the weasel is fatal.

Pliny couldn't believe the following, however—by a Grecian author of note:

> A member of the family of one Anthus is chosen by lot and then taken to a certain lake in the district, where after suspending his clothes on an oak, he swims across the water and goes away into the desert, where he is changed into a wolf and associates with other wolves for a space of nine years. He returns to the same lake, swims across, resumes his original form, only with the addition of nine years to his former appearance—and takes his former clothes as well.

Pliny adds:

> It is really wonderful to what a length the credulity of the Greeks will go.

We are quoting this to prove that his own credulity had a boundary.

He believed that certain animals possess knowledge of medicinal remedies, and devotes a whole chapter to that subject—every statement of which is doubtless fabulous. The dragon, he says, relieves itself of nausea which affects it in the spring, with the juices of the lettuce. The elephant counteracts the poison of a devoured chameleon by means of the wild olive, and the stag, the effects of poisonous plants by eating artichokes. Wood-pigeons, partridges and blackbirds purge themselves once a year by eating bay leaves—ducks, geese and other aquatic birds by vervain—cranes with bulrush, etc. Canine madness is fatal to man during the thirty days heat of the star Sirius; but dogs will never become rabid if on the fortieth day after the birth of the pup the last bone of the tail is bitten off. He says nature has also bestowed upon animals the

power to presage wind, rain and storm, each in its own peculiar way, and accepted as "Science" divination from birds as practised at Rome.

Pliny's is a ponderous work—thirty-seven volumes in "Natural History." He has been justly called a "compiler of anecdotes" rather than a naturalist. He performed the service, however, of keeping alive interest in natural objects, but perpetuated a mass of falsehoods which supplied delectable pickings for the blind centuries that followed. Even by some in the nineteenth century he has been spoken of as the "greatest naturalist of antiquity." He certainly wasn't that and it would appear in the light—or rather darkness—of succeeding ages, he not only performed no very valuable service to natural history other than that mentioned above, but rather added a lot of matter which would have to be discarded before real progress could be made.

Pliny turned the trend downward—the retrograde movement culminating in that period generally known as the Middle Ages. It is not necessary to go into the difficult task of explaining the existence of such a period.

The domination of the Christian Church by the clergy did anything but quicken interest in the study of nature or any other kind of science. It was an age that could debate with fervor the question as to how many angels were able to stand on the point of a needle but the prevailing asceticism and scholasticism brought about abhorrence for all earthly subjects. It was thought idle to give attention to the study of plants and animals, for the world was soon to come to an end anyway and the best preparation for the event was to give one's self up to pious meditation.

The theologians made the Bible the unfailing, infallible guide on all questions. To pry into the secrets of nature was regarded as impious, since the Creator revealed Himself all that He willed in the Bible itself. But the mention of animals and other natural as well as miraculous phenomena in the Old Testament led the theology of the period to produce a natural history peculiarly its own.

It is rather interesting to see what would happen in science under such auspices and against such a background.

The standard theological text-book of science was the "Physiologus." Under this title are embraced some fifty Christian allegories. As its imagery is almost wholly taken from the animal world, it is also known as the Bestiary.

There were current at the time many marvelous descriptions of animals—and descriptions of some marvelous animals—by such vague authors as "the naturalists" or "the naturalist" or under the vague title of "History of Animals," but the "Physiologus" came to be the one generally accepted and quoted by the clergy and most widely known among the people.

Andrew D. White, who has been the most persistent student of this period, says the "Physiologus" remained the principal source of thought on animated nature for a thousand years. A translation of this remarkable book may be found in the Harvard Library—a version by Phillip de Thanu (1121), an Anglo-Norman poet, whose work is edited by Thos. Wright (1841).

In his preface Wright claims that the "Physiologus" was "founded on the Natural History of Pliny with a mixture of medieval fables, many of which had been borrowed directly or indirectly from the Orientals."

The original Greek manuscript was composed probably at Alexandria sometime during the second and third centuries.

The theologians of the medieval period were not prepared to question any of the animal tales then current, no matter how unreasonable or phantastic they might be. Investigation, observation and experiment were entirely omitted. Whenever questions of any sort arose, whether in theology or natural history, the advantage lay with the one who could cite most authorities and marshal the material in a form that would be most convincing. It is said that a long and spirited discussion took place as to how many teeth are found in the horse, but none of the debaters thought of looking into the horse's mouth.

The theologians had but one use for zoological knowledge, anyway—to illuminate their texts. Contributing as it did to the various necessities of the pulpit and people, the "Physiologus" came to be of no very definite content—great liberties were taken not only with the outward form, but modifications and additions were made to suit the purpose of the one who used it. So it is hardly to be considered a literary work at all; nevertheless its symbols found their way into the rising literature and had a powerful influence on the fancy of artists employed upon church buildings and furniture. In fact the "Physiologus" is the key to the meaning of much medieval sculpture and many paintings found in European churches to-day.

As a book it had many versions in Latin, German, French and English and still exists in about a dozen languages East and West.

With such a wonderful history it is not a wonderful piece of literature. It embraces, as has been mentioned, fifty allegories, which were supplemented by descriptions of the miraculous power of precious stones.

The characteristics of animals, real or imagined, are mentioned only to adorn the moral that follows.

That of the *lion* is quite typical:

What is in Greek *leun* has in French the name King. The lion in many ways rules over many beasts, therefore is the lion king, now you shall hear how—

He has a frightful face, the neck great and hairy, he has the breast before square, hardy and pugnacious—his shape behind is slender, his tail of large fashion and he has flat legs constrained down to the feet—he has the feet large

and cloven, the claws long and curved—when he is angry or ill-disposed he devours animals without discrimination—as he does the ass which resists and brays, Now hear without doubt the signification of this.

The lion signifies the Son of Mary—He is the King of all people without any gainsay—He is powerful by Nature over every creature and fierce in appearance with fierce look. He will appear to the Jews when He shall judge them, because they made themselves guilty when they hanged Him on the cross—and therefore they have merited to have no king over them.

The square breast shows strength of the Deity—by the tail is indicated justice, which is placed over us—by the leg which he has flat he shows that God was constrained; and it was necessary that He give Himself for us—by the foot which is cloven, is demonstrance of God—who will clasp the world, will hold it in His fist; by the claws is meant vengeance upon the Jews: By the ass, we understand the Jews very rightly; the ass is foolish by nature as the Scripture says; he will turn from the way, if one does not drag him entirely to it.—Just such nature have the Jews who are as fools—they will never believe in God unless they do it by force; they will never be converted, etc.

The lion when he will hunt and will eat prey, with his tail in truth, as is proved, he makes a track on the earth and leaves an opening that it may be an entrance to the beasts which he desires—and such is his nature that there will never be any beast which will pass over his mark or go beyond it.

The tail by its nature shows Holy Scripture—and the tail is justice which is placed upon us; by the track we understand Paradise rightly, and the breach is the entry which is prepared for us, if we do good and avoid evil.

The lion when he is angry, he hangs himself by his feet—he will hang himself in the earth when he is enraged.

We understand Christ in the semblance of the lion, etc., etc. . . .

Again Scripture says the lion has this nature—when we hunt him with his tail in flying he erases his track on the ground that we may not know how to seek him—remember this is a great signification.

The lion in flying covers his track—the track of the lion means incarnation which God would take on earth to gain our souls—and thus truly he did covertly —he placed himself in degrees of which each order was, of prophets, of apostles, until he was carnal man and was mortal for us . . . and thus he vanquished the Devil. . . . The lion fears the white cock and he has such a nature that he sleeps with his eyes open—the white cock signifies men of holy life. . . .

The lioness when she brings forth a dead cub, holds her cub and the lion arrives. He goes about it and cries till it revives on the third day.

Having read the allegory of the lion one can judge pretty easily the correct interpretation of the others.

The devil has his counterpart in the dragon, crocodile, onocentaur, the salamander, the siren, the serpent, the hedge-hog, the monkey, the fox and the whale. Hell is the track made by the lion's tail, or it is the fox's hole, or the depths of the sea; Christ—the lion, the eagle, the goat, the phœnix.

Some very surprising statements are made about these animals:

The *serpent*, cunning, sly, and aware of evil . . . when it perceives people who want to enchant it, will press an ear against the earth, into the other press its tail firmly that it hear nothing of the enchantment—persons bitten by snakes will sometimes dry up and die by burning.

The *hedge-hog* after mounting the grapevine, throws to the ground the ripest of the clusters, then descends and rolls upon the grapes, sticking them to its prickles and thus carries food to its offspring.

The *fox* covers itself with red earth, and lies down as dead. The bird, which sees it, thinking it is dead, will come to peck at it—into the fox's mouth it will put its head and beak. The fox takes the bird with a jump and devours it.

The *wild ass*, on March 25th brays 12 times, also 12 times in the night. This is to indicate that day and night are of equal length.

The *monkey* carries its favorite offspring in front, those it hates, at its back.

The *whale* places the sand of the sea on its back, and remains tranquil. The sea-captain, spying this apparent island, disembarks and builds a fire thereon. The whale feels the fire and plunges with ship and people into the sea. The whale has such a nature that when he wants to eat he begins to gape . . . and sends forth a smell so sweet and so good that the little fish, who like the smell, will enter into its mouth.

The *eagle* carries its young toward the sun and only the fledglings that gaze straight at the sunlight are acknowledged by the eagle as kin. . . . Physiologus says further, of the eagle, when it becomes old and feels its wings heavy, and when its sight fails, then it mounts high in the air and burns itself in the intense heat—then it goes to the east, sees a clear fountain wherein it dips three times and becomes young again.

The *phoenix* is a bird which is very elegant and handsome—it is the only bird of its kind in the world, and its color is all purple—it lives 500 years or more. In old age it burns itself by the sun's rays sitting above a heap of spice twigs . . . and is reduced to powder and on the third day comes to life.

Caladrius is the name of a bird, all white. It can distinguish in a man the infirmity he has—truly if he must die it will not deign to look at him, but if it will look at him, know of a truth that by its look it takes all the man's ill, draws all the disease to itself and the man recovers.

The popular natural history up to the seventeenth century was of similar character.

It would appear that the "Physiologus" and like productions shaped the early drama. We refer to the miracle plays of the Church in which the reader will remember that the Devil and other leading characters were shown by representations of animals.

Shakespeare's times were characterized by gross misconceptions of animal life—the ideas inherited from the Middle Ages and sometimes even improved upon. His plays are full of references of this kind, but that does not mean, of course, that he himself believed them; but if he sought knowledge from what had been written he must have gotten very many erroneous notions of animal life about him. Holland's Pliny was read by some and probably there existed other works on more scientific principles, but they were in Latin and published abroad.

There can be little doubt that Bartholomew's "On the Properties of Things," written about the middle of the thirteenth century, was the standard authority of the period. Bartholomew was an English Franciscan monk, who began with the intent of explaining the allusions in Scripture to natural objects, but expanded his work to a survey of all nature. It was translated into the principal languages of Europe and

was widely read. For three hundred years it maintained its position—even after the invention of printing there were editions in several languags besides ten editions in Latin. As usual his descriptions were cast in a theological mould. Fabulous creatures of Scripture—the unicorn, dragon and leviathan—are described in detail.

Of the *Unicorn* he says:

> It is a right cruel beast and hath that name for he hath in the middle of the forehead a horn 4 ft. long and that horn is so sharp that he throweth down all that he rageth on. And this beast fighteth oft with the elephant. And the unicorn is so strong that he is not taken with the might of hunters, but a maid is set there, and the unicorn cometh and layeth his head on her lap, and leaveth all his fierceness and sleepeth.
>
> There be many kinds of unicorns—Monoceron is a wild beast shaped like to the horse in body and to the hart in head, and in the feet to the elephant, and in the tail to the horse.

Bartholomew says:

> If a crocodile findeth a man by the water's brim he slayeth him if he may—and then weepeth over him.
>
> When father and mother crows wax old and feeble, then the young crows underset them and rear them up with their wings . . . and bring their members that be diseased into state again.
>
> Dolphins follow man's voice and come together in flocks to the sound of symphony. They leap over ships, etc.

In Bartholomew the descriptions of animals are not supplemented by the minute allegory of the Middle Ages, still animals exist only to teach moral lessons. Some are made, he declares, as lions and tigers, so that man should realize his own infirmities; flies and lice to torment him; noxious animals of all kinds were created to punish him for his sins.

Sir John Mandeville was another contributor to zoological knowledge. His work is entitled "Voiage and Travaile, which treateth of the way to Jerusalem and of marvyles of Inde with other islands and countryes." This is a translation from manuscripts of about the middle of the fourteenth century.

It is in the quaint English of three hundred years ago, and seems to have been very popular. Toward the close of that century more manuscripts may be found of Mandeville's book than of any other literary production, except the Bible.

He is very careful to assure his readers that he is telling the truth. In one place he devotes nearly a half page in coating his story with pious assertions. That his readers required some means of assurance is evident, when one reads of his "folk in Ethiope, that have but one leg and they run so fast that it is a marveyle, and the foot is so large that it shadoweth all the body against the sun when they wish to lie and rest."

He avers that there are rats in China as large as hounds. In another isle, fishes of a certain kind come once a year and cast themselves upon the bank in such great multitudes that nothing but fish

can be seen. And there they remain three days and men gather as many as they like. But after the third day the remaining fish go back into the sea. After them come a multitude of another kind, and after them still another, till all the diverse manner of fishes have been there. Mandeville adds: "It is the most marveylle that ever I saughe."

He speaks of an entire island eight hundred miles long, literally filled with serpents, dragons and crocodiles. The island was supplied with an abundance of water, a great lake formed from the tears of Adam and Eve, who wept on the mountain above for one hundred years, after they were driven out of Paradise.

In the same country and others about are wild geese that have two heads. In India he found hens without feathers, but they had white wool like that of sheep.

In "Caldilhe" (wherever that might be) he found a "fruyt" growing on trees as though they were gourds. When they are ripe men cut them in two and find within a little beast, in flesh, bone and blood like a little lamb, but without wool.

Mandeville mentions at this point that he told the natives about the "goose barnacles" of his own country, which also were supposed to grow on trees, and to fall off into the water and swim about like geese.

In another place he found a people who live entirely on the smell of wild apples.

His travels contain a full account of many of the animal stories of the "Physiologus," including the fierce ants that hoard up gold, which is gotten from them by sending across the stream to the meadows where they dwell, mares loaded with empty baskets. These are filled by the ants and the mares return to their offspring.

In Mandeville and Bartholomew allegory is either wanting or used sparingly. But the purpose of both was to contribute to the edification of the saints.

There is some question whether Mandeville spent thirty-four years in the East, as he claimed, or traveled there at all. His tales, however, were popular reading during the period of discovery in the latter part of the fifteenth century, when the imagination was quickened by the return of explorers from new countries across the seas.

Besides Bartholomew and Mandeville there were several other authors whose descriptions of the wonders of nature found favor, among them Topsell's "History of Four-Footed Beasts and Serpents" (1658), Harrisons's "Description of Britain" (1577) and Lupton's "A 1,000 Notable Things" (1595). These were, in substance, similar to those from which we have quoted, and contain many of the same accounts, sometimes in new form.

Rather earlier than the publication of these came the re-discovery of Aristotle's history, and the effect was that naturalists again sought to learn by observation of real animals.

We see this influence in the work of Edward Wolton, an English physician, who published in 1552 his "De Differentibus Animalium." It was based on Aristotle, with additional matter.

In the year previous appeared Gesner's first of five volumes, a "History of Animals," of over three thousand pages and nearly a thousand excellent figures. His great service was the introduction of good illustrations. In his volumes are retained a few pictures of the sea-serpent and mermaids, but Gesner ranks as the most brilliant zoologist between Aristotle and John Ray.

It would appear that Ray was the Moses that led the theologians out of the wilderness, in publishing toward the close of the seventeenth century his "Wisdom of God Manifested in Works of Creation," which passed through twenty editions. Ray argued the adaptation of animals not only to man's uses, but to their own lives and surroundings.

This conception of "creative design" while it can not be regarded quite the modern scientific attitude, which would make every tub stand on its own bottom, did bring about some really good work. The science of the period was in full accord with the theological notion that animals and plants had for their main purpose, the "profit, instruction, enjoyment, and amusement of man."

Ray's work probably inspired Paley's "Natural Theology" of the same century, and led to the Bridgewater Treatises of the middle of the nineteenth. The latter was the fruit of a provision in the will of the Earl of Bridgewater, by the terms of which the President of the Royal Society selected eight persons, each of whom received a £1,000 for writing and publishing a treatise "on the power, wisdom and goodness of God, as manifested in the Creation."

The leading essays were Chalmer's "Adaptation of External Nature to the Moral and Intellectual Condition of Man," Bell's "The Hand as Evincing Design," Roget's "Animal and Vegetable Physiology with Reference to Natural Theology," Kirby's "Habits and Instincts of Animals with reference to Natural Theology."

Only the last bears directly on natural history. If the others are as good as Kirby's, the Bridgewater Treatises were a very great advance over anything that had come previously from the church.

Kirby's is almost entirely free from fable and contains much real zoological matter. Such scientific investigators as Lamarck and Owen are frequently quoted and the attempt to give a true account of animal life seems to be adhered to.

But the author never loses sight of his main purpose and he is very careful to keep strictly to the orthodox account of creation. Scripture content forces him to retain the dragon, but he gives him a zoological classification and would fix his native abode in subterranean waters.

REASONING FROM ANALOGY AT ZUÑI

By ELSIE CLEWS PARSONS

NEW YORK CITY

EXCEPT in the most scrupulous scientific circles this type of thinking is prevalent and perhaps it is invidious to particularize its products in any given community. But during a recent visit to the Southwest I was so freshly impressed by the way pueblo life may be colored by such reasoning I am tempted to describe it in the setting presented to me, the daily life of the Zuñi and their life at times of individual crisis.

On the west side of Towa Yalene or Corn Mountain, the side facing the pueblo about three miles away, stands a great semi-detached, pinnacle rock, Akaipa, "Wide Rock, the Zuñi call it. Part of it from a certain angle would seem to represent a man followed by a woman with a child on her back. In one of the Zuñi myths the pinnacles represent the five children of the boy and girl once thrown in sacrifice off the top of the mesa into the mounting flood below. But whether from its conformation or the tradition attaching to it, either way by a process of analogy, the rock has become the gaol of phallic pilgrimage. Pictographs of the organs of reproduction are cut upon it in several places, thanks to more reasoning by analogy, and prayer plumes are planted in one of its secluded turns. Faces are cut on the plume sticks and on the stick for a boy a bit of turquoise blue is painted—in Zuñi classification the turquoise is male.

There is another phallic shrine not on but near the great mesa and again its magic is based on analogy. It is a hollow loop of piled up stones, open at one end—the *asha* or vulva no doubt, and, completing the symbol, half-buried, into the interior projects a longish stone. From this stone a bit is chipped and powdered and given in water to the would-be mother of a girl.

A would-be mother, one whose children have died, has still another method of imitative magic at her disposal. Every four years the Zuñi go rabbit hunting with their gods, *i. e.*, with the masked figures who personate their divinities. Foremost in the hunt is the figure of the Chakwena *okya,* the Chakwena woman. Before the hunt the blood of a rabbit has been rubbed on her legs and in the hunt she must take a straight line through whatever plants are in her course that the blood may be wiped off on them, thereby ensuring fertility alike to

rabbits and to the women of Zuñi. Rabbits are prolific and their young vigorous, hence, you understand, the connection. But an even more intimate association may be made between the Chakwena and the would-be fruitful woman. After the hunt the Chakwena retires to one of the sacred club-houses, the Hekiapa *kiwitsine, kiwitsine* of the nadir, and there for four days she lies in on the conventional child-birth sand-bed. During this confinement the would-be mother looks after her. An ear of corn represents the infant.

In beliefs about twins reasoning by analogy plays a part. Unless a woman wish to conceive twins she should not eat at the same meal venison and beef or venison and mutton. Besides, as deer, you see, bear twins, the woman who eats a piece of the wafer bread that has been taken on a hunt to be sacrificed to the deer, that woman will certainly bear twins—unless the bread has been passed four times around the rung of her house ladder.[1]

Would she give birth to a girl no man must be present in the house during her labor. As girl babies are much desired in Zuñi this belief is probably one of the reasons the resident American physician, a man, has no obstetrical cases among the Zuñi. The last child of my Zuñi hostess, a Cherokee married to a Zuñi, was a boy. She had wanted a girl. "But you should not have had in the American doctor then," her Zuñi friends had said to her, "nor the children's father."

Pregnancy lends itself generously among the Zuñi as elsewhere to analogy. No pregnant woman would look upon a corpse, her child would be still-born or born living would soon pine away. A pregnant woman is told too not to stand at windows, at delivery the child too would stay still before the prospect of the outer world; nor should she eat piñon nut, a rather greasy nut, as the child's head would be covered with grease, delaying its delivery. On the other hand to hasten parturition, one woman told me, a woman in labor should eat a bean—beans grow up quickly.[2]

Albinoism is caused, it is believed, by injudicious eating, by eating the white leaf within the husk of the corn, before conception if it is the father who eats, after it, if it is the mother. Pimples on the infant's face are caused during pregnancy by the mother sprinkling bran on the floor of her oven—a Zuñi method of testing for temperature. Birth marks or deformities of one kind or another are also caused by care-

[1] In this discharming act I suspect some analogy, but I fail to clearly distinguish it.

[2] To the Hopi woman a bit of weasel is given to eat—weasels go quickly through a hole. On the wrist of her infant son a Hopi ties a *bi-mo-nuh,* a very swift running insect—to make the boy a good runner. (Owens, J. G., "Natal Ceremonies of the Hopi Indians," pp. 165, 173. *J. Amer. Ethn. and Archeol.,* II. (1892).)

lessness on the part of one parent or the other before the birth of the afflicted child. The carelessness may be in connection with some ceremonial or with some animal. Some feature of the ceremonial would seem to be "caught" by the child. A member of the Newekwe Fraternity told me, for example, that his son was marked at birth with the print of an entrail across chest and forehead. It was to have been expected, for during his wife's pregnancy had he not taken part in his fraternity's ceremonial, a ceremonial peculiarly concerned with animal entrails?

Hunting is taboo an expectant father, lest his child suffer in some way analogous with that his quarry suffers. Were a rabbit or a prairie dog shot in the eye or wounded in the leg, the child would be born blind or lame. The head of one little girl I knew was a bit flattened on one side, because, they said, her father had gone prairie-dog shooting before she was born and he always shot his prairie-dogs in the head. The jaw of a kinsman of this child was malformed, under size and twisted to one side. One of his parents had perhaps broken the jaw of a sheep, it was said, before his birth. A baby that cries all the time is supposed to have pain in its back and this is caused by his father having overdriven his horses, his whip presumably to their backs, before the birth of the child. But the greatest casualty to which a man may subject his unborn offspring comes of killing a snake. The child will be marked like a snake, oh ye shades of Elsie Venner!—and die.

Were a child slow in teething, a man who had been bitten by a rattlesnake would be called in. He would rub the gums of the infant and dentition would follow—rattlers, one is told, have two teeth. It would not do to use a comb on a baby's head; for its teeth would come in brittle and spaced wide, like the teeth of a comb.

That a baby may not cry too much during its infancy, soon after birth its attendant holds her hand over its mouth. A wakeful baby is charmed to sleep by a feather under its pillow. It is the feather of the *mewichokwe,* a bird that sleeps much of the time.[3] This feather was once used too for obvious reasons in war magic. When preliminary to an attack upon their hereditary enemy, the Navaho, the Priest of the Bow crept at night into the Navaho encampment, he would bury there a prayer plume, a stick with six feathers, the feathers of the four birds sacred to the gods of war, the eagle, the duck, the hawk, the, in Zuñi, *tsililigo.*[4] The fifth feather is that of the *aake* (named from

[3] Among the Hopi the leaves of a plant named for the bat are used. (Hough, W., "The Hopi," p. 58. Cedar Rapids, 1915.)

[4] The "dancing" bird I used to call it from its conspicuous flights at dawn. After a brief sail through the air it stops short and for a few moments in just the same spot it works its wings even more vigorously than a dancer his legs. That *is* its dance, say the Zuñi. Whether from this analogy or not the

its call), a fool bird as we would say, a bird which flutters about without a purpose, irresponsibly, so to speak. The sixth feather is that of the *mewichokwe*. A *mewichokwe* feather in their midst, the enemy is naturally drowsy and off guard and the next morning when they do wake up they lose their heads like the *aake* and go wandering about, aimless and weaponless, easy victims to the ambushed Zuñi.

From the soporific functions of a bird I pass to the detective functions of a deer. The wife of a man out hunting is supposed to "stay still," not to leave the house except at noon time to fetch water. On the way to the well she will sprinkle the sacred meal. It is the time when her hunting spouse will be thirsty, and when the deer will begin to move about. If that afternoon the hunter is successful, he knows his home-staying wife is properly devoted to him. If he is unsuccessful, he suspects her of gadding about. Of worse things even he will suspect her if he see a buck and a doe together and the buck mounting the doe. It is the way the deer take to "tell" him what is happening at home. He has then to kill the deer and take out their hearts. On his return home he will find both his wife and her lover sick. And unless he rub them with deer heart mixed with meal, the woman with the heart of the doe, the man with that of the buck, they will die.

The dead are buried with their head to the East, ready to arise, one informant suggested, facing Kothluwala, the Sacred Lake to which they are to journey, a journey sixty-five miles to the west of Zuñi. People will not sleep with their heads to the East. And a child who falls asleep careless of its position will be asked, "Why do you want to sleep like a dead person?"

longish tail feathers of this bird are much prized for prayer plumes. A little fellow in my household caught a *tsililigo* in a hair trap one morning and straightway he had out the tail feathers from the still living bird and had carried them to his grandfather.

LOST MOUNTAINS OF THE PRAIRIES

BY CHARLES KEYES
DE MOINES, IA.

NOWHERE perhaps on the face of our globe does there exist a bit of landscape more picturesque, more unexpectedly novel, or more curiously wrought into strong contrasts of relief than that found about the point where meet the three great prairie states of Iowa, Minnesota and South Dakota. It is in the very midst of the Great Plains which stretch out unbrokenly from the Arctic ocean to the Mexican gulf. It is a part of that tract which early French explorers and *coureurs de bois* were pleased to call the Coteau des Prairies; and which an English trapper designated the Height of Land. For its size and altitude it is the most scenic spot on earth.

In this region are perfectly represented in miniature some of the grandest relief features of every clime: Grand Canyon of Arizona, the Royal Gorge of Colorado, the majestic escarpment of Glorietta, the pinnacled Dolomites of the Eastern Alps, the rock-walled lakes of northern Italy, the boiling rapids of Finnish Imatra, the leaping brooks of Norway, the broad water-curtain of Niagara, and about all the boundless Girghiz steppes. In days gone by also there covered this land glaciers compared with which existing ice-fields sink into utter insignificance. Formerly lofty volcanoes poured forth their floods of molten rock. Alone of all great landscape types mountains are missing. Once these too were here; but to-day they lie buried beneath the level of the singularly flattened and monotonous prairies.

At the present time there are, within the limits of the area of which we speak, few traces in any of the relief features to indicate that there ever existed here a high and mighty mountain range. The ground is perhaps a little higher than it is either to the east or to the west. The country to the north is indeed a low watershed. Plain is the dominant topographic expression of the entire region. In all directions the eye has unobstructed view for distances of many miles. Even the horizon is unbroken by hill-form or valley depression; it is as straight as the sky-line at sea. Travelers at the railroad stations see afar a full half-hour before the train arrives the black smoke-cloud of the approaching locomotive.

Of the lofty mountains which once loomed up on the horizon every vestige at the surface has long since vanished. They are leveled to the sea, lost and forgotten. To-day their foundations are being slowly

FIG. 1. CANYON OF THE SIOUX RIVER; a remarkable meeting of antithetical relief types.

exhumed by the corrading action of stream and rain: and here and there the old structures are being brought to sky. The traces are many but inconspicuous. Recently through means of the records of many deep-well borings and other data the height, extent and form of the

FIG. 2. DEPTHS OF THE SIOUX CANYON AT THE DELL RAPIDS.

FIG. 3. JASPER POOL; an old canyon filled with glacial débris.

ancient mountain range has been fully figured forth, and its characteristic features pictured out. This great earth-wrinkle which sprang from the sea in Mesozoic times extended from the east shore of present Lake Superior southwestward beyond the path of the Missouri River. Medially the rocks were bowed up more than a mile above the existing level of the prairies. In their prime these Siouan mountains rivaled in scenic beauty and grandeur the Adirondacks, the southern Appalachians or the Juras of to-day. Then Jove and Boreas and Vulcan each laid claim to them; and each did his work of demolition quickly and well. They reduced the majestic pile of adamantine down to the very level of the ocean, when Neptune gathered it to his own.

Although now no remnant of former mountains remains in the relief expression of the region and the entire area of once high altitudes is as level and as smooth as any other part of the vast interior plain there persists beneath the glacial mantle mountain structures as well pronounced and as typical as they are anywhere else in the world. The broadly arched strata, the folded formations, the faulted rocks, the intrusions of once molten magmas, the prodigious extravasations of volcanoes, are familiar features which here are characteristically developed. The evidences of orogenic uprisings are unmistakable. Seldom to the geologist are mountain phenomena more clearly depicted. Form, extent and stratal attitude are measurable with great precision.

The discovery of the old and long-buried mountain range is a matter so recent and so instructive that a brief statement of the manner of its finding is not without distinct interest. It well illustrates the

and cloven, the claws long and curved—when he is angry or ill-disposed he devours animals without discrimination—as he does the ass which resists and brays, Now hear without doubt the signification of this.

The lion signifies the Son of Mary—He is the King of all people without any gainsay—He is powerful by Nature over every creature and fierce in appearance with fierce look. He will appear to the Jews when He shall judge them, because they made themselves guilty when they hanged Him on the cross—and therefore they have merited to have no king over them.

The square breast shows strength of the Deity—by the tail is indicated justice, which is placed over us—by the leg which he has flat he shows that God was constrained; and it was necessary that He give Himself for us—by the foot which is cloven, is demonstrance of God—who will clasp the world, will hold it in His fist; by the claws is meant vengeance upon the Jews: By the ass, we understand the Jews very rightly; the ass is foolish by nature as the Scripture says; he will turn from the way, if one does not drag him entirely to it.—Just such nature have the Jews who are as fools—they will never believe in God unless they do it by force; they will never be converted, etc.

The lion when he will hunt and will eat prey, with his tail in truth, as is proved, he makes a track on the earth and leaves an opening that it may be an entrance to the beasts which he desires—and such is his nature that there will never be any beast which will pass over his mark or go beyond it.

The tail by its nature shows Holy Scripture—and the tail is justice which is placed upon us; by the track we understand Paradise rightly, and the breach is the entry which is prepared for us, if we do good and avoid evil.

The lion when he is angry, he hangs himself by his feet—he will hang himself in the earth when he is enraged.

We understand Christ in the semblance of the lion, etc., etc. . . .

Again Scripture says the lion has this nature—when we hunt him with his tail in flying he erases his track on the ground that we may not know how to seek him—remember this is a great signification.

The lion in flying covers his track—the track of the lion means incarnation which God would take on earth to gain our souls—and thus truly he did covertly —he placed himself in degrees of which each order was, of prophets, of apostles, until he was carnal man and was mortal for us . . . and thus he vanquished the Devil. . . . The lion fears the white cock and he has such a nature that he sleeps with his eyes open—the white cock signifies men of holy life. . . .

The lioness when she brings forth a dead cub, holds her cub and the lion arrives. He goes about it and cries till it revives on the third day.

Having read the allegory of the lion one can judge pretty easily the correct interpretation of the others.

The devil has his counterpart in the dragon, crocodile, onocentaur, the salamander, the siren, the serpent, the hedge-hog, the monkey, the fox and the whale. Hell is the track made by the lion's tail, or it is the fox's hole, or the depths of the sea; Christ—the lion, the eagle, the goat, the phœnix.

Some very surprising statements are made about these animals:

The *serpent*, cunning, sly, and aware of evil . . . when it perceives people who want to enchant it, will press an ear against the earth, into the other press its tail firmly that it hear nothing of the enchantment—persons bitten by snakes will sometimes dry up and die by burning.

The *hedge-hog* after mounting the grapevine, throws to the ground the ripest of the clusters, then descends and rolls upon the grapes, sticking them to its prickles and thus carries food to its offspring.

The *fox* covers itself with red earth, and lies down as dead. The bird, which sees it, thinking it is dead, will come to peck at it—into the fox's mouth it will put its head and beak. The fox takes the bird with a jump and devours it.

The *wild ass*, on March 25th brays 12 times, also 12 times in the night. This is to indicate that day and night are of equal length.

The *monkey* carries its favorite offspring in front, those it hates, at its back.

The *whale* places the sand of the sea on its back, and remains tranquil. The sea-captain, spying this apparent island, disembarks and builds a fire thereon. The whale feels the fire and plunges with ship and people into the sea. The whale has such a nature that when he wants to eat he begins to gape . . . and sends forth a smell so sweet and so good that the little fish, who like the smell, will enter into its mouth.

The *eagle* carries its young toward the sun and only the fledglings that gaze straight at the sunlight are acknowledged by the eagle as kin. . . . Physiologus says further, of the eagle, when it becomes old and feels its wings heavy, and when its sight fails, then it mounts high in the air and burns itself in the intense heat—then it goes to the east, sees a clear fountain wherein it dips three times and becomes young again.

The *phoenix* is a bird which is very elegant and handsome—it is the only bird of its kind in the world, and its color is all purple—it lives 500 years or more. In old age it burns itself by the sun's rays sitting above a heap of spice twigs . . . and is reduced to powder and on the third day comes to life.

Caladrius is the name of a bird, all white. It can distinguish in a man the infirmity he has—truly if he must die it will not deign to look at him, but if it will look at him, know of a truth that by its look it takes all the man's ill, draws all the disease to itself and the man recovers.

The popular natural history up to the seventeenth century was of similar character.

It would appear that the "Physiologus" and like productions shaped the early drama. We refer to the miracle plays of the Church in which the reader will remember that the Devil and other leading characters were shown by representations of animals.

Shakespeare's times were characterized by gross misconceptions of animal life—the ideas inherited from the Middle Ages and sometimes even improved upon. His plays are full of references of this kind, but that does not mean, of course, that he himself believed them; but if he sought knowledge from what had been written he must have gotten very many erroneous notions of animal life about him. Holland's Pliny was read by some and probably there existed other works on more scientific principles, but they were in Latin and published abroad.

There can be little doubt that Bartholomew's "On the Properties of Things," written about the middle of the thirteenth century, was the standard authority of the period. Bartholomew was an English Franciscan monk, who began with the intent of explaining the allusions in Scripture to natural objects, but expanded his work to a survey of all nature. It was translated into the principal languages of Europe and

method of modern scientific venture beyond the confines of the known. By peeling off, as it were, the thick Cretacic and glacial coverings of the area the entire Mesozoic floor is laid bare, and the Paleozoic formations then constitute the uninterrupted bed-rock of the whole region. By what is essentially the same thing elimination of these later coverings is accomplished by plotting the numerous deep-well records and other data relating to the underground structures.

Casually referring to a general geological map of the area, the various Paleozoic terranes are seen to be distributed in relatively narrow belts trending in a northwest direction. Singularly these belts in southern Minnesota abruptly terminate. The cause has been long perfectly inexplicable. It is now found that the most ancient rocks form the core of a rather notable arch, the axis of which is directed northeastwardly. It is a true anticline structure of large proportions and great longitudinal extent. After the country had been bowed up it was planed off quite to sea-level. It is against this anticline that the belted Paleozoics are upturned and cut off. Indeed, they too once extended unbrokenly over the old arch. In northern Minnesota and in Manitoba the same belted formations abruptly appear again. The discovery is a result of inductive reasoning that is quite remarkable. The whole problem was in fact fully worked out before its proofs were even sought in the field. Lines of reasoning and results of extensive direct observation are in strictest accord. Discovery was made before the facts themselves were even presented.

Rarely in so small compass is there so well displayed the effects of every great geologic process known. For countless ages fire, flood and frost have played upon these rocks without completely effacing

FIG. 4. PALISADES OF THE SIOUX RIVER, rivaling those of the Hudson and the Rhine.

FIG. 5. SPIRIT CANYON; more impassable than the Royal Gorge.

them. Volcanic outbursts have seamed, seared and smelted these formations until often they are almost beyond recognition, but they are not yet destroyed. When rains have failed to wash these rocks away or the rivers have been unable to wear them down, the sea has time and again cut into them or carried them hundreds of fathoms deep, yet they have reared themselves again above the surface of the engulfing waters. Heat of sun and chill of ice have alternately contended in flaking off the rock surface; still they have ever presented new faces to these insidious attempts at their destruction. Winter blasts and the siroccan winds of summer have blown the rock-areas bare and clean as a city

FIG. 6. THE SIOUX FALLS; near which Gitche Manito the Mighty once touched Earth.

FIG. 7. GLACIAL SCORINGS ON AN ICE-PLANED SURFACE OF SIOUX QUARTZITE.

pavement, and the wind-blown sands and dusts have rounded off all corners and polished all surfaces until the hard vitreous blocks appear as if fused in a furnace, without seemingly making any marked impression. Continental glaciers have repeatedly passed over the region, planing off the glassy masses as a joiner does his beam of wood, and deeply grooving the smoothed facets as by some giant graver. Compression and arching of the earth's crust have uplifted the country into mountains, but they have signally failed to destroy the rocks.

FIG. 8. FAMOUS PIPESTONE QUARRY; for fifty centuries the calumet has been the symbol of universal peace.

The sudden appearance and rapid decline of the Siouan mountains on the mid-continental horizon are incidents of the Mesozoic age of geologic history. Brief, brilliant, almost pathetic are the succession of chief events. The main uplifting took place during the Triassic period. In the succeeding Jurassic and Comanchan times all of the ranges were completely razed to the present plains-level. During Cretacic time the waters of the ocean again rolled unbrokenly over the old base-leveled region, and the bared foundations of the former mountains formed the bottom of the broad epi-continental sea. No great orogenic uplift was ever more rapidly or more completely obliterated. It is one of the marvelous episodes in the long history of the North American land contest.

In still another way the Siouan area is quite notable—perhaps the most remarkable spot of our country. It is one of the completest of outdoor laboratories for geological instruction. With an areal extent scarcely larger than that of some of our larger cities it is a unique study-ground. It is a veritable geologic *multum in parvo.* In this circumscribed district is represented every known category of the geological agencies. The whole panorama of geological science is spread out before one's eyes. Apt illustration abounds of the major phenomena pertaining to the origin, structure and modification of the earth's crust.

The Siouan area is a locality where the cardinal principles of earth science may be best taught by example, and in the least possible period. In a week's time the entire list of principal processes and products may be passed in review in the field. In going to and from this spot another week's time permits examination of the most complete stratigraphic section of the continent and a review of the evolution of life generally. As the culmination of a year's study of geological science indoors this place is well worth a visit by every college student and teacher in geology. It is, in fact, the most typical, most compact, and illuminating area yet revealed wherein students may perform in a little while extensive geologic field-work of a most practical kind. It is here that the outlines of field-geology are acquired at a glance. The foundations are here quickly laid for all the broader and subsequent geologic excursions into the farthermost points of earth.

The realm of the ancient Siouan mountains is also famous in poetry and Indian lore. Principal scenes of Longfellow's "Song of Hiawatha" are laid here, although when he wrote the epic it is not probable that the poet had ever been nearer the place than the Cambridge gardens on the shores of Back bay.

In the unwritten annals of the Sioux Indians, who once roamed over a large part of the continental interior, the Des Moines river was known as the Inyan-Sha-Sha-Watpa, literally, "Stone-red-red river," or the Redstone river. This Indian name has peculiar significance. When European eyes first beheld it and for a period of more than two centuries thereafter this noble stream was the only all-water route in all the land by which without getting out of his boat Indian and fur-trader could traverse the continent from the Arctic Ocean to the Gulf of Mexico.

The headwaters of the Des Moines River, or Inyan-Sha-Sha-Watpa, are in the red quartzite district of the old Siouan mountains; but the red stone is the more famous catlinite found associated—the much-sought stone from which the calumet or peace-pipe was wrought. From the pipestone ledges of the broad prairies spread peace on earth and good will towards men to the farthermost limits of the continent, to

FIG. 9. JUXTAPOSITION OF OLDEST AND YOUNGEST ROCKS OF EARTH.

the remotest corner of the Indian world. Forty centuries before the Nazarene appeared on earth this spot was solemnly consecrated to the cause of world-wide peace. Peace at once reigned among warring nations wherever the smallest fragment of this red rock was carried. The redstone calumet was the most potent power in the adjudication of international disputes that ever came into the hands of man. It would have been most fitting had the great Temple of The Hague been erected over the quarry from which this magic stone is obtained. It is yet left to us to rear on this spot some noble shaft to point out by simple symbol the highway to universal peace.

Far View House, Mesa Verde National Park, Colorado, View from the South. (*Photographed by G. L. Beam.*)

THE PROGRESS OF SCIENCE

ARCHEOLOGICAL WORK IN THE MESA VERDE NATIONAL PARK IN 1916

During the summer of 1916, Dr. J. Walter Fewkes, ethnologist of the Bureau of American Ethnology, at the request of the Department of the Interior, uncovered in the park a large mound of stone and earth near Mummy Lake, within sight of the government road and a little over four miles from Sprucetree camp. The building brought to light, shown in the illustration, is a community house of the pueblo type, and is highly instructive as the first of its kind ever excavated on the plateau. Its bearing on the morphology of pueblo architecture is regarded as of scientific importance.

From the summit of the mound chosen for excavation, there is a wide outlook into four states—Colorado, Utah, New Mexico and Arizona—which has suggested the name, Far View House. The mound was both the most important and the largest member of a group of mounds, sixteen in number, irregularly scattered over an area a half mile north and south, and about half the same distance east and west. Each mound in the group is surrounded by a level space showing evidence, in places obscure, of irrigation ditches from a reservoir of considerable size, misnamed Mummy Lake, situated at the northern border of the area. This group of mounds is typical of several others found in clearings among the cedars on top of the plateau. These clearings can easily be detected by a dense growth of sagebrushes, covering mounds with worked stones strewn over their surfaces but not now arranged in walls.

It has been recognized for several years that these clusters of mounds indicate the existence of open sky buildings, but the forms and architectural features of these concealed structures were unknown. It was, therefore, thought to be an important work to open one of these mounds to serve as a type for comparison with other prehistoric dwellings in the park, especially the cliff dwellings. Similar mounds occur in other regions of the southwest, the first requisite for a morphological comparison with which would be a knowledge of architectural characters impossible to obtain from a superficial examination of the mounds.

In surface features the mound chosen for study does not differ from others in the same cluster. Each has a depression in the center, and is accompanied by a low mound, the surface of which was bare of artificially worked stones, situated a few feet to the east or south. This smaller mound is the cemetery, the greater part of which had been dug over by seekers for mortuary pottery. The scarcity of salable objects found in the larger mounds has preserved these mounds, although trenches have been dug across them to determine that fact. The first work to be done by the systematic archeologist was to cut off the bushes and remove fallen stones and accumulated soil. When this had been accomplished there was revealed a rectangular building facing south, measuring 113 feet long on the north, by a hundred feet on the east side. Within this enclosure closely packed together were rooms, while on the south side there was revealed a court surrounded by a wall a few feet high. The building uncovered was formerly three stories high on the north side, sloping in terraces toward the south from which the distant view above referred to is spread before the visitor. It is estimated that

MODEL OF FAR VIEW HOUSE, MESA VERDE NATIONAL PARK, COLORADO, FROM ELEVATION OVER SOUTHWEST ANGLE.

the highest or north wall, now reduced in height, formerly measured about 18 feet. No doorways were found through the surrounding wall, a fact suggesting the use of ladders to mount to the terraces. Within the surrounding walls there were no evidences of streets or courts, but the walls of all the rooms were compactly united, necessitating entrances to many of the rooms through hatchways in the roof. Several rooms, however, could be entered directly from the court on the south side.

It was evident from the inception of the work that Far View House was formerly inhabited. Numerous objects of household use were found in the rooms, several of which had fireplaces in their floors, while others showed evidence of smoke on their walls. Mills for grinding corn, still in place, emphasized the fact of former human occupancy and showed their domiciliary use.

Two different types of rooms occurred in this unique building. The most prominent were circular in form. One of these measured 32 feet in diameter and occupied the middle of the building, and around it there were irregularly placed three others. The shape and other features of these rooms indicated ceremonial rooms constructed on the same lines as similar rooms in the cliff dwellings.

By far the larger number of rooms in Far View House are rectangular, often with passageways from one to another. They served for storage of food or other wealth, and for shelter, but many occupations as cooking and manufacture of pottery of the inhabitants must have been performed on the terraced roofs of these buildings.

The architectural structure of Far View House indicates that it was a pueblo or community building, differing mainly from neighboring cliff dwellings in its situation and lack of cave covering. The similarities in construction show an identity in culture of the inhabitants. The cliff dwellers and inhabitants of the mesa villages were the same people.

The relative age of Far View House and a typical cliff dwelling, like Cliff Palace, is impossible to determine, but the indications are that the open-air house was built later than the dwelling protected by the overhanging roof of a cave. We have no means of determining the chronology of either in terms of the Christian era. The amount of accumulation of wind-blown sand in the rooms and the reduction in height of the tops of the walls by stones falling from them show that considerable time had elapsed since Far View House was abandoned. The causes that led the inhabitants to desert Far View House, and what became of them are in part suggested by a comparison of the form of

Far View House with that of other ruins. The essential features of the type are its rectangular form and round kivas with rooms in a compact mass. Similar ruined peublos occur in several localities in Colorado and northern New Mexico but we have good reason to believe that this type of building is characteristic of a circumscribed area and is no longer erected. The people who lived in houses of the same type some distance from Mesa Verde must have brought to that plateau this peculiar form, or the inhabitants of the Mesa Verde must have carried the same type into distant regions of the area where the type occurs. The indications are that the latter supposition accounts better than the former for the diffusion of the type.

The cause of the desertion of the Mesa Verde buildings may be found in a desire to settle in better localities, as their numbers increased. No indication of a drying-up of the country, by which the crop of their food material was lessened, is in evidence, for it is probable that corn, their main food supply, could still be harvested near Far View House, especially by a people acquainted with artificial irrigation. An increase in number of inhabitants may have given them confidence that they could defend themselves from any enemies, if they descended to the river valley, and led them to emigrate, not as a body, but in small bands, appropriating localities better suited for agriculture than the farms they once had. Constant bickering of clans, disease, quarrels of various kinds had much more to do with hastening their departure than inroads of aliens or hostile nomads.

Far View House probably shares its architectural characters with other buildings on top of the mesa. All the different modifications in external form of Mesa Verde pueblos can be known only after others are uncovered, but the indications are they have certain features in common. Among these may be mentioned the central circular ceremonial room, the rectangular chambers clustered about it with partitions united to it, and the fortification-like wall surrounding them both. It is evident that in this type defense is combined with habitation, but the enemies to be feared were mainly domestic, not foreign. Enemies from the valley could not make their way to the top of the mesa and attack these towns with any show of success. Far View House was built for protection against men of their own tribe. Each group of mounds was composed of similar buildings. Those of the same group may have been peacefully disposed to each other, but judging from what we know of the pueblos of the present day, each cluster had frequent conflicts with their neighbors over ownership of the scanty water supply or boundaries of their farms; even trivial disagreements over rabbit hunts or other matters may have led to serious consequences.

It is desirable now that one of the villages in the Mummy Lake group is uncovered to continue this work with a view to determine the relationship to it of other adjoining habitations, now in ruins. Questions of social organization of the inhabitants of the different pueblos of a group with a partial amalgamation are important, and facts bearing on other points may be gathered by renewed archeological activity on the mesa. Nowhere are conditions for the study of primitive American architecture more propitious than here, where different types of prehistoric buildings occur a short distance apart. Once determined on the Mesa Verde, the character of prehistoric social life here discovered may afford a good type for comparison of culture in other ruins scattered over a wide territory of the southwest, survivals of which are detected in the inhabited pueblos, for it must be borne in mind that the Mesa Verde and neighboring country is regarded as the place where the pueblo culture originated. It might be added that here it reached its highest development in architectural forms.

CLEVELAND ABBE
In whose death America has lost its most distinguished meteorologist.

THE GEORGE ROBERT WHITE MEDAL OF HONOR.

THE GEORGE ROBERT WHITE MEDAL OF HONOR FOR HORTICULTURE

IN the year 1909 Mr. George Robert White, of Boston, presented to the Massachusetts Horticultural Society a fund, now amounting to $7,500, the income of which is to be devoted annually for the purpose of providing a substantial gold medal to be awarded by the executive management of the society to the man or woman, commercial firm or institution in the United States or of some other country that has done the most in recent years to advance the interest in horticulture in its broadest sense. This award is to be known as the George Robert White Medal of Honor and has been awarded every year since its foundation.

The awards thus far made are as follows:

1909. To Professor Charles S. Sargent, director of the Arnold Arboretum, Jamaica Plain, Mass.

1910. To Jackson Thornton Dawson, the well-known and accomplished plantsman of the Arnold Arboretum.

1911. To Victor Lemoine, of Nancy, France, the originator of many of the popular varieties of flowering plants to be found in the gardens of to-day.

1912. To Michael H. Walsh, the rose specialist of Woods Hole, Mass., the originator of the Lady Gay rambler rose and of many other popular varieties.

1913. To the Park Commission of the City of Rochester, N. Y., in recognition of its tasteful work in landscape planting.

1914. To Sir Harry James Veitch, of London, England, seedsman and nurseryman, and the introducer and propagator of many desirable ornamental garden plants.

1915. To Ernest Henry Wilson, of Boston, for his botanical and horticultural work in China and Japan and the discovery of many new varieties of flowering plants, shrubs and trees.

1916. To William Robinson, of London, England, for his educational work in horticultural literature.

The medal is of coin gold, weighs eight and a half ounces, and is struck at the Mint of the United States in Philadelphia. It was designed by John Flanagan, the eminent medalist, and is considered a work of much artistic merit.

The award of this medal every year is of value as a recognition of the labors of those who have done so much for the advancement of the interest in horticulture and who have added to the enrichment of our gardens.

THE COUNCIL OF NATIONAL DEFENSE

THE Council of National Defense and its advisory commission, composed of civilians, have decided to appoint seven committees to further develop the program for the mobilization of the resources of the country. They have issued the following statement:

The program of the council and commission has for its object the provision of an adequate military and naval defense based on an adequate industrial and commercial coordination and preparation. To attain this end, a definite, immediate and continuing program is being worked out.

The commission has divided into committees. A member of the commission is the chairman of each of the committees. Committees have been formed to take charge of the following subjects, and other committees will be formed as they may be needed.

A. Medicine, including general sanitation, Commissioner Franklin H. Martin, chairman.

B. Labor, including conservation of health and welfare of workers, Commissioner Samuel Gompers, chairman.

C. Transportation and communication, Commissioner Daniel Willard, chairman.

D. Science and research, including engineering and education, Commissioner Hollis Godfrey, chairman.

E. Raw materials, minerals and metals, Commissioner Bernard Baruch, chairman.

F. Munitions, manufacturing, including standardization and industrial relations, Commissioner Howard Coffin, chairman.

G. Supplies, including food, clothing, etc., Commissioner Julius Rosenwald, chairman.

The chairman of each committee will call a series of conferences with representatives of trades, businesses or professions. At such conferences the representatives shall be asked to organize so as to deal with the council through one man or through a committee of not more than three men, to whom the council shall submit problems which may affect the national defense and welfare.

One or more members of the council will meet the conferees and set forth the desires of the government and its needs. To quote the words of the enabling act, these needs are "the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the nation."

SCIENTIFIC ITEMS

WE record with regret the death of Edward Dyer Peters, professor of metallurgy, and Charles J. White, professor emeritus of mathematics, Harvard University; of Arnold Valentine Stubenrauch, professor of pomology, University of California; of Jules Dejerine, the French neurologist, and of Friedrich Hahn, who occupied the chair of geography at Königsberg.

THE portrait by Henry Ulke of Joseph Henry, first secretary of the Smithsonian Institution, has been transferred by a senate resolution, from the capitol to the Smithsonian Institution, where it has been hung in the National Gallery of Art, in the new building of the National Museum.—The library of the late Professor Hugo Münsterberg has been given to Harvard University by a group of his friends. The library consists of about 10,000 books, reprints, pamphlets, manuscripts, charts and other papers.

DR. VERNON M. SLIPHER, for many years chief assistant at the Lowell Observatory, known for his spectroscopic researches, has been appointed director of the Lowell Observatory in succession to the late Percival Lowell.

THE National Canners' Association has offered Harvard University the sum of $20,000 annually for a period of three years to carry on an investigation of food poisoning or so-called ptomaine poisoning, with special reference to canned goods. The offer has been accepted by the university, with the understanding that the investigation shall be conducted and the results thereof published with entire academic freedom. The study will be made at the Medical School under the direction of Dr. M. J. Rosenau, professor of preventive medicine and hygiene.

Vol. 4, No. 5 MAY, 1917

THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: Sub-Station 84

Single Number, 30 Cents Yearly Subscription, $3.00

THE SCIENTIFIC MONTHLY

MAY, 1917

THE FUR-SEALS OF THE PRIBILOF ISLANDS

By Professor G. H. PARKER
HARVARD UNIVERSITY

IT has often been said that more legislation has been devoted to the northern fur-seal than to any other animal. So far as the United States is concerned, this statement is not surprising, for the revenue that has been derived from these animals since 1867 when our government acquired possession of their principal breeding place, the Pribilof Islands, has been more than ten millions of dollars. This large sum does not represent all pure gain, but the profits included in it must have gone a long way toward meeting the seven million dollars and more that the United States paid Russia for the whole of Alaska including the Pribilofs. And, if the Alaskan account is not already settled by the past income from the seals, it can be so discharged with a very little care. Of all the treasures in Alaska, the seals are probably among the most valuable. Unlike mineral wealth, they need never run out, for, in consequence of their powers of reproduction, they can yield under reasonable control a large and continuous revenue for an indefinite future. It is therefore easy to understand the unusual occasion for legislative activity in behalf of these animals and indeed any government would be most negligent of its interests did it not exert itself to the utmost to maintain and improve so valuable a source of income.

The popular idea of seals comes mostly from the hair-seals which are common in the harbors and along the shores of many countries. These animals are noted for their agility in the water, but on land they are clumsy and awkward. The fur-seals are not closely allied to the hair-seals, but find their nearest relatives in the sea-lions, whose skill on land is often attested by their remarkable acrobatic performances in zoological gardens and even on the stage. The fur-seal, though apparently not so skilful as the sea-lion, is thoroughly at home on land and walks and runs like a short-legged bear. Hence it has often been called the sea-bear. It is also a most skilful and adroit swimmer.

The fur-seals of the North Pacific are represented at present by three herds (Fig. 1). A small one of perhaps ten to twelve thousand

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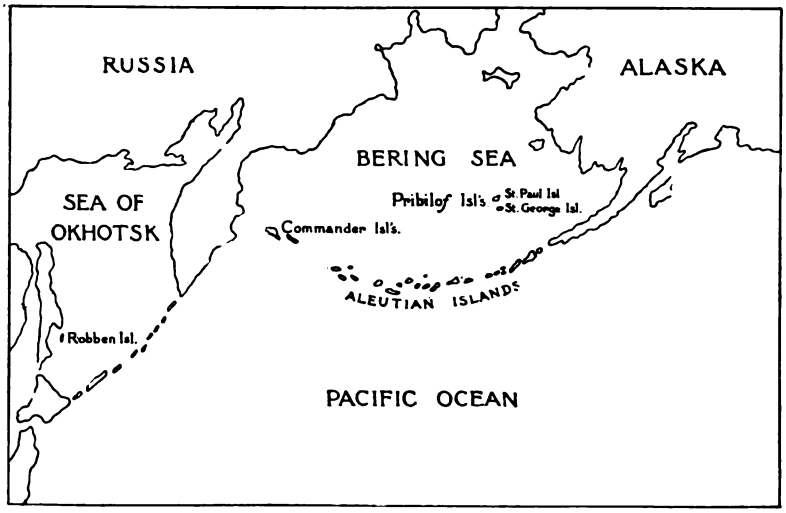

Fig. 1. Outline Map of the North Pacific and Bering Sea, showing the locations of the breeding grounds of the three fur-seal herds: Robben Island, the Commander Islands, and the Pribilof Islands.

individuals breeds on Robben Island in the Sea of Okhotsk and is supposed to have a migration route in the Sea of Japan. This herd is now under Japanese management. A second and larger herd breeds on the Commander Islands west of the Aleutian chain. These seals are said to migrate along the eastern coast of Japan and are under the control of Russia. By far the largest herd is that which breeds on the Pribilof Islands. Its winter migration route lies southward through the passes of the Aleutian Islands into the Northern Pacific with a return route along the west coast of North America. This herd is under the management of the United States. All three herds are supposed to be quite distinct and not to mingle in their migrations. Each probably represents a distinct species.

The discovery of these seal herds is due to the early Russian naviga-

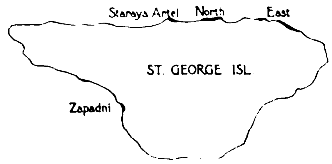

Fig. 2. Outline Map of St. George Island, showing the location of its four fur-seal rookeries.

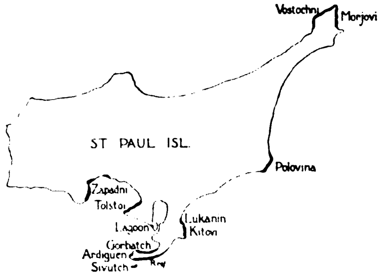

Fig. 3. Outline Map of St. Paul Island, showing the locations of its twelve fur-seal rookeries.

tors. Late in the year 1741 Bering, in returning from his second voyage to the North Pacific, with a crew sick and much reduced, reached the Commander Islands rather by good fortune than by good seamanship. On the island subsequently named for him the expedition was forced to winter. Here scurvy still further reduced the crew, and among those who died was Bering himself. In the following spring, Steller, the naturalist of the expedition, reorganized the party for its return, but, before its departure, the arrival of the fur-seals took place and thus was disclosed to Steller the breeding haunt of what has ever since been the chief body of the Russian herd. Later navigators, in their explorations of the Aleutian chain, tried to follow the fur-seals that were seen in migration in the passes of these islands and thus to discover their breeding places. But none of these efforts were successful till 1786 when Pribilof made his way through the mists and fogs of Bering Sea to Saint George Island, where he came upon the hosts of fur-seals that breed on its shores. Although only forty miles distant and under a clear sky easily visible from Saint George, the larger and richer island of Saint Paul was not discovered till a year later, a fair commentary on the prevailing weather of this region. Thus the two great seal islands of Bering Sea were thrown open a little over a century and a quarter ago to the Russian traders. With our purchase of Alaska from Russia in 1867 these islands became a part of the United States.

Both islands are of volcanic origin, though at present no active volcanoes or even hot springs are found upon them. Their general surface is composed of lava rock, boulders and volcanic sands. There are no trees upon them, but in the short summer they are covered with a coarse, luxuriant tundra growth. Neither island has a good harbor and the weather is often so tempestuous that they afford practically no lee to vessels. Saint Paul is a succession of low rolling hills. Saint George is more precipitous, some of the cliffs on the shore rising to a height of a thousand feet or more. Saint Paul is a little over thirteen miles in total length and Saint George not above twelve. Yet these two islands whose total area is not so much as eighty square miles have yielded the unusual revenue already noted. Who can tell what the rest of Alaska with an area of more than half a million square miles may yield?

When first discovered the islands of Saint George and Saint Paul were without human inhabitants. The Russians, however, soon brought to their shores as a means of carrying on the seal industry a number of Aleut Indians and these intermarrying with the Russians gave rise to the present so-called native population. These natives are gathered together in a village on each island. In 1914 the village of Saint George contained 116 natives distributed in twenty-four households and

FIG. 4. MATURE BULL IN PRIME CONDITION AWAITING THE ARRIVAL OF THE COWS. Kitovi Rookery, June 22, 1914.

the village of Saint Paul 192 natives in fifty households. Besides the natives, each village contains a few whites: a government agent, doctor, school-teacher, store-keeper, radio-operator and the like. But interesting and commercially important as the natives are and fascinating as are the herds of reindeer, foxes, and sea-lions, and the great bird rookeries of the Pribilofs, none of these can compare with the long stretches of beach occupied by thousands upon thousands of fur-seals. Indeed it is highly improbable that there exists anywhere else on the surface of the globe such a huge exhibition of mammalian life as on the shores of these islands.

A strange terminology has grown up in the description of the fur-seals. Full-grown male fur-seals are called bulls and the mature females cows. Their offspring are known as pups. The young males before sexual maturity are termed bachelors. A bull with his assem-

FIG. 5. WAITING BULLS ON SIVUTCH ROOKERY, June 29, 1914.

blage of cows is called a harem and a succession of harems on a beach constitutes a rookery. Strange and incongruous as this usage may seem, the individual terms when taken in relation to the particular aspect of the herd to which they refer are found to be descriptively most appropriate, and the observer in spite of his sense of the proprieties of language is brought quickly to adopt them.

The seals do not locate indiscriminately on the beaches of the Pribilofs, but repair year after year with great regularity to particular stretches, the so-called rookeries. Judging from the conditions of the shores and the declarations of the natives, these rookeries have been remarkably constant for many years past. They still retain for the most part the Russian names that were given them in the early days of their discovery. At Saint George four such rookeries can be distinguished (Fig. 2). On the shore of the island near the village are East

FIG. 6. TWO COWS WITH BULL. Probably Gorbatch Rookery, late in June, 1914.

Rookery, more or less subdivided, North Rookery, and Staraya Artel, probably indicating, as the Russian name implies, the location of one of the original settlements. Across the island from the village is Zapadni or the West Rookery. On Saint Paul there are no fewer than a dozen active rookeries (Fig. 3). At Northeast Point are Vostochni or East Rookery, and Morjovi or Walrus Rookery. Polovina or Halfway Rookery is between Northeast Point and the village of Saint Paul. Not far to the northeast from the village itself are Lukanin Rookery and Kitovi Rookery. To the south and southwest of these are Reef Rookery, Sivutch Rookery on Sea-lion Rock, and Ardiguen and Gorbatch rookeries. North from the village is the small Lagoon Rookery.

FIG. 7. A HAREM ON GORBATCH ROOKERY; the bull with many cows and new-born pups. July, 1914.

And on either side of English Bay are Tolstoi Rookery and the more or less divided Zapadni or West Rookery. It is on these situations, and not on the beaches in general, that the fur-seals congregate in enormous numbers for their breeding season. In consequence the rocks in these regions have become worn and smoothed so that even in the absence of seals a rookery site can be distinguished from that of an ordinary beach.

During the late winter all the fur-seals are at sea, but as summer approaches they migrate toward the Pribilofs, and in favorable seasons they begin to appear on the island rookeries as early as April. The first to come are the adult males or bulls (Fig. 4). The few that may appear in April take their places on the beaches and are quickly followed in May and the early part of June by the remainder of their kind. By the middle of June the great majority of the full-grown bulls have established themselves on the beaches to await the coming of the cows (Fig. 5). At this stage the bulls are in marvelous form. Their pelts are heavy and firm and their bodies in prime condition. In weight they are not far from 400 pounds. They seem to be possessed of inexhaustible energy. They will charge any intruder, man or beast, and drive him from their preserves. They move with a curious loping gait which may be about as fast as a man can run over a rough beach. After fifty to a hundred feet of such travel they usually desist, apparently from lack of wind. Their object at this season seems to be to defend their chosen territory from invasion, and this they will do to the bitter end. It is practically impossible for a human being to dislodge them and if another bull opposes them, they will slash him over the head, breast and fore flippers with their protruding canines till the blood and fur fly in all directions. Such contests are carried out with an enormous amount of snorting, hissing, and enraged breathing

that make them most exciting to the onlookers. The object of this whole performance is the maintenance around the bull of a certain area of clear beach in which the cows will eventually assemble. Deaths are apparently not common in these early struggles, though the strain of the situation is often to be noted in the scarred and bloody condition of many of the combatants. The term "beachmaster" is an appropriate designation for those of the bulls that maintain their places against all comers.

As the bulls are establishing themselves, the cows begin to arrive (Fig. 6). They are relatively small, timid creatures, weighing on the average about seventy pounds. They begin to appear near the tenth of June and continue coming till well into July or even August. Those that arrive early make their way in among the bulls without exciting great attention. They wander about somewhat aimlessly but eventually associate themselves with a given bull, after which they are treated by him as part of his growing harem and more or less jealously guarded. Thus each harem as the season progresses gradually increases in the number of its cows.

The maximum size of a harem can not be stated with accuracy, for as the season advances the cows are in and out of the water continually (Fig. 7). In 1914 the number of cows associated with one bull varied by actual count from 1 to 106. The average harem in that year, obtained by dividing the total number of breeding cows by the number of harem bulls, was approximately 60. It is probable that this number is somewhat too high for the best condition of the herd. There is,

FIG. 8. DISORGANIZING HAREMS TOWARD THE CLOSE OF THE SEASON. Gorbatch Rookery, August 6, 1914.

FIG. 9. ONE OF THE LAST BULLS TO LEAVE GORBATCH ROOKERY; the beach shows a preponderance of pups. Gorbatch Rookery, August 6, 1914.

however, no reason to believe that an average harem of 40 is in any sense an excessive number. What the average harem was in the original condition of the species and before man's intervention, can not be stated with certainty. It is believed to have been not over 40 and it may not have been less than 30.

The cows that arrive from the open sea are gravid females. Within a day or so after they have come ashore and joined a harem, they give birth to a single pup, and probably within a week after the birth of their young they are in heat and impregnated by the bull. The usual period during which the young are carried must, therefore, be a year less about a week. There is apparently no ground whatever for the

FIG. 10. TOWARD THE CLOSE OF THE SEASON; only cows and pups on the beach. Tolstol Rookery, end of August, 1914.

supposition that the fur-seal breeds biennially and that its period of gestation is approximately two years.

After the cow has been impregnated, the bull is less solicitous about her and she leaves the harem from time to time for the open sea and feeding. During her absence, which at times may possibly cover a period of a couple of days, her pup fasts, but on her return he gorges himself with her milk.

As the season progresses and the pups are born and the cows impregnated, the vigilance of the bulls declines and in the latter part of July and especially in August (Fig. 8) the harems begin to disintegrate and the rookeries become one vast confusion of bulls, cows, and pups (Figs. 9, 10, 11). The bulls, as a result of their incessant activities, are in a state of extreme emaciation. Many of them have been on the beaches from May and during the period between the time of their arrival and the end of July or early part of August, they touch no food. This fast of well over two months coupled with their incessant activity drains them of all their stored energy. Their fat disappears and they are reduced almost to skin and bones (Fig. 12). In this state they may be driven off a rookery without resistance and they soon return to the sea to begin the winter migration. During this period they feed and fatten in preparation for the coming season. Thus early in August or even in July the bulls, who were the first to announce in the spring the coming of the herd, are also the first to take departure and begin the winter movement. They are followed gradually by the rest of the colony (Figs. 13, 14) and by November the rookeries are almost deserted, a few seals occasionally lingering on till well into winter.

From time to time during sealing operations many seal pups have been branded in such fasion as to allow them to be followed year by year as they grew up (Fig. 15). In this way a rough idea of the age of the fur-seal has been arrived at. It seems highly probable that the bulls and cows have approximately the same length of life, namely, from twelve to fourteen years. The bulls begin breeding at about the sixth or seventh year, though some may begin a year or so earlier, and are thus active for about half their lives as breeding individuals in the herd. As young animals they are known as bachelors up to about their fourth year after which they are commonly spoken of as half-bulls till about their seventh year, when they assume the condition of the mature bull. The cows first pair with the bulls at two years of age and bring their first pup to the islands at the close of their third year. If, as is supposed, they live to be twelve to fourteen years old and produce one pup a year, they must add to the herd in the course of a lifetime ten to a dozen new individuals.

About the habits of the cows little more need be said than has already been given in the general account of the formation and disin-

FIG. 11. TOWARD THE CLOSE OF THE SEASON; bachelors mingling with cows and pups. Tolstol Rookery, August 23, 1914.

tegration of the harems. As already remarked, the cow is a relatively small animal, weighing not more than a fifth or sixth as much as a bull (Figs. 16, 17). They are on the whole timid and can be driven off the beach at almost any time. In the fighting of the bulls they often intervene in a strange way by clinging to the throat of the bull at the onset, after which very little real disturbance is likely to occur. If, however, the contest is really on and a cow comes in the way of the bull, she is likely to be seized by him and thrown bodily some distance back into the harem as a kindly reminder that the field of battle is not the place for females.

After the birth of her pup and her reimpregnation, the cow is free to make excursions from the harem into the open sea for feeding and she may travel in quest of food to a distance of fifty or a hundred miles from the island. On her return she searches long among the pups and eventually accepts one to whom she then gives milk (Fig. 18). With thousands of pups on the beach, it seems incredible that a cow after an absence of a day or more should find her own offspring, but, judging from her actions, she seems to be able to accomplish this feat. With the growth of the pup, she becomes less and less attached to the harem and, as these disintegrate in the latter part of July and early in August, she becomes a general inhabitant of the beach. Here she remains till November, when she takes to the sea for the winter migration.

The pups, one for each cow, are born shortly after the arrival of the cows, that is, between the middle of June and the latter part of July, thought newborn pups have been seen occasionally as late as August. At birth they weigh about eleven pounds. They come into the world commonly attached to the placenta, from which they are sooner or later freed by the breaking of the umbilical cord (Fig. 19). The vast number of placentas thus left upon the beach, together with the seal excrement, chiefly from the pups, gradually decompose in the cold northern air and give to the rookeries a penetrating odor, not to say stench, that can be recognized a mile or more away when the wind is in the right direction. This odor can be described as a strong stable smell with a slight aromatic turn to it. It is probably common to most seals and was certainly familiar to the ancients, for we are told in the fourth book of the Odyssey that when Odysseus and his men hid among the seals to surprise Proteus, each held beneath his nostrils some ambrosia with which to overcome the stench from the surrounding animals.

At the height of the season the rookeries are not only permeated by characteristic odors but are the scenes of the utmost confusion. The bulls hissing, snorting, and bellowing, the cows calling in a sheep-like bleat to their pups, and the pups responding in a higher pitch all contribute to a bedlam of noise which deafens the onlooker and has to be experienced to be appreciated. Into this malodorous tumult and con-

fusion the fur-seal pup is born, and yet from the beginning he seems to be quite at home and he certainly thrives under conditions of filth where most animals would be expected to perish outright. His habits are extremely playful (Fig. 20). He is continually rolling about and tugging and pulling at his companions. If a person stoops down in a group or pod of pups, coat tails and trouser legs are likely to be seized and tussled by these little creatures in a way that is wholly pup-like, and the appropriateness of the name becomes at once evident. Till the first week in August the pup remains strictly on shore, after which he begins to take to the water, first paddling and then swimming. Thus he starts his preparation for the winter migration when in November as a plump little seal with a weight varying from twenty-five to fifty pounds he deserts his birthplace on his first migration southward.

FIG. 12. SPENT BULL AT THE CLOSE OF THE BREEDING SEASON. Gorbatch Rookery.

The bulls, cows and pups occupy the real breeding areas of the rookeries, but besides these spaces there is also in every rookery of considerable size an extended area occupied by the young males or bachelors. These areas are known as the bachelors' hauling grounds and are usually to one side of the breeding grounds proper and have free and independent connections with the sea (Fig. 21). Here during the breeding season the young and immature males or bachelors congregate and live a life more or less independent of the rest of the herd. The bachelors begin to arrive on the islands with the bulls, the older ones coming first and the younger later, and they remain till the end of the season, being usually the last ones to depart in December or even later in the winter. They are quite what their name implies, being an unattached, rollick-

ing and disturbing element in the herd. They are incessantly in and out of the water and are known to migrate between the islands during the breeding season (Figs. 22, 23).

With the bachelors are the half-bulls, six or seven years old, and as the harems disintegrate toward the end of the breeding season, these young bulls make their way in among the breeding members of the herd and often establish temporarily a small harem of two or three or more cows which have escaped from other harems or have arrived very late for breeding activities. In this way recruits from the bachelors' hauling grounds are introduced into the herd proper and thus year by year the worn-out bulls are replaced by new and younger stock.

Some uncertainty has prevailed as to the return of yearling seals to the islands, but it now seems to be quite clear that this really occurs. This very young stock, however, does not come to shore until after the actual breeding season is over. It is possible that a few may reach the beaches in the latter part of July, but the majority certainly do not come till after the middle of August. When they arrive, they do not haul out with the bachelors, but come to shore where the harems have disintegrated and associate themselves chiefly with the pups, from which they do not differ greatly in size. The pups on leaving the islands in November have an average weight between 37 and 38 pounds. When they return in the following August as yearlings, their weights range according to actual records between 33 and 41 pounds. Apparently during their nine months at sea they have not gained much in weight, if in fact they have not lost, but they have exchanged fat for muscle and thus have laid the foundations for that career of vigor and exertion to which all successful fur-seals must look forward.

The main facts in the life of the fur-seals, both male and female, are thus fairly well established. Many details are still to be added, but in general the life history of this species is well worked out. Born as a pup in one year the male yearling returns late in the season of the next year to play on the breeding grounds with the pups of that year. As a two-year-old on his second return to the islands he enters the ranks of the bachelors, where he remains till his sixth or seventh year, when as a half-bull he begins to take part in the breeding of the herd. He now transfers all his activities to the breeding grounds and as a full-grown bull or beachmaster works at the establishment of a harem season after season till his end comes at approximately his twelfth or fourteenth year.

The activities of the cows run a somewhat different course. The cow pup after her first migration probably returns to the islands as a yearling late in the second season to play among the pups as the yearling males do. On her second return as a two-year-old she arrives on the breeding grounds a little in advance of the disintegration of the

Fig. 13. Cows and Pups Swimming. Vostochni Rookery, August 17, 1914.

harems. She enters one of the harems formed late in the season by the younger bulls and becomes impregnated for the first time. In consequence of this her first pup is brought to the island at the end of her third year when she enters regularly into the breeding activities of the herd and adds a pup to the seal population for each subsequent year in her life. Thus the fur-seal herd maintains itself through the intensive and regular but relatively brief breeding season on the islands alternating with the annual winter migration of some six to nine months during which its members spend their whole time in the open ocean, for, though their migration route extends as far south in the Pacific as Southern California, they are never found close to shore.

The only way the early Russian sealers had of procuring the skins of the fur-seal was by capturing these animals in the open sea during their migrations. After their breeding haunts were discovered, land killing became the customary method and for this purpose in 1799 the Pribilof Islands passed into the control of the Russian-American Company. This company killed for their pelts large numbers of young seals, both male and female, till 1835, when the herd was so far reduced that restrictive measures were deemed necessary. Between 1786 and 1834 it is estimated that nearly two millions of seals were taken on the Pribilofs. From 1835 to 1867 the killing was more restricted and female seals were spared, a practice which has ever since been adhered to. As a result of these regulations the herd increased and, though over 600,000 skins were taken between 1835 and 1867, the herd when it passed into the hands of our government was variously estimated as containing from two to six millions of animals.

Under the management of the United States the privilege to kill seals on the Pribilofs was leased in 1870 to the Alaska Commercial Company for twenty years. On the expiration of the lease, a second one for another twenty years was made to the North American Commercial Company. This new lease expired in 1910, after which the government abandoned the leasing system and undertook the management of the herd itself. From the time when the Pribilofs passed into the possession of the United States till the end of the second American lease in 1910, over 2,500,000 skins were taken on the islands, and during this period, especially the latter half of it, the herd showed a steady decline in numbers. The cause of this decline was much discussed, but it is now generally agreed that it was not due to the regular killing on land, but to the practise of pelagic sealing which as an occupation had steadily grown.

In the early years of the sealing industry a certain number of seals were killed at sea during their migration or while on their feeding excursions from the islands. The sealers who obtained skins in this way were known as pelagic sealers. They were not very numerous till 1879,

after which they increased very considerably in numbers till the practise was put down. At first the pelagic sealers were chiefly Canadians and Americans, but in later years many Japanese were engaged in this business. The pelagic sealers not only often captured more seals than were killed on the islands, but they killed in addition many seals that could not be retrieved and whose bodies were lost in the sea beyond recovery. Moreover from sixty to eighty per cent. of their catch were females whose pups must subsequently have died of starvation and whose importance for the further maintenance of the herd there and then ceased. It is, therefore, not surprising that with the development of pelagic sealing the herd should show a steady decline.

FIG. 14. YOUNG SEALS ON TOLSTOI BEACH, August 25, 1914.

Recognizing this fact, the United States took steps to protect its seal herd, with the result that it became involved in a controversy with Great Britain, some of whose citizens were active in pelagic sealing. It was finally decided by the two powers concerned to submit the whole matter to a tribunal of arbitration to meet in Paris in 1893. Meanwhile Great Britain agreed to prohibit British subjects from sealing in the eastern part of Bering Sea and the United States prohibited all killing of fur-seals whatever by its citizens except that 7,500 should be killed annually as food for the Pribilof natives. This agreement, commonly known as the "Modus vivendi," originally applied only to the year 1891, but it was renewed for 1892 and 1893.

As a result of the deliberations of the Paris tribunal, pelagic sealing was prohibited in a zone of sixty miles radius around the Pribilofs

and was prohibited entirely between May 1 and July 1. These regulations, which were subject to reexamination at intervals of five years, went into effect in the summer of 1894. Nevertheless the catch from pelagic sealing continued to increase and the seal herd correspondingly continued to decrease. In 1896 the United States accepted the proposal of Great Britain to institute independent investigations of the entire question at the close of the five-year trial period. These investigations were made in 1896 and 1897 and the voluminous report of the American investigators was published in 1898. Meanwhile Congress toward the close of 1897 had enacted a law forbidding citizens of the United States from engaging in pelagic sealing at any time or place.

A new lease to the North American Commercial Company was not granted when in 1910 the old one expired, but the United States government assumed the full management of the herd. Toward the close of the following year a treaty was made effective between the United States, Great Britain, Russia and Japan, whereby sealing on the high seas was abolished for a period of fifteen years. By its provisions the United States and Russia, as owners or guardians of the seal herds, agreed to pay both to Great Britain and to Japan, for the relinquishment of their interest in pelagic sealing, fifteen per cent. each of the income from the United States and the Russian herds. In like manner Japan agreed to pay to the United States, to Great Britain and to Russia ten per cent. each of the value of the catch from her small but growing herd. Finally in 1912 in consequence of the reduced state of the Pribilof herd, the Congress of the United States passed the present law to the effect that no fur-seals should be killed on the Pribilofs for a period of five years except such as were needed as food for the natives, and that a breeding reserve of not less than five thousand three-year-old males be made annually during the life of the treaty suspending pelagic sealing. For some time past it had been the rule to make some form of count of the Pribilof fur-seals as an indication of the state of the herd. Since 1896 counts of the actual number of harems had been made annually. These counts had been carried out at what is called the height of the season, usually between the tenth and twentieth of July. Since 1912 the total number of pups born in the season has been counted and on the basis of the count of pups and of harems a fairly accurate estimate of the total strength of the herd has been made.

Proteus is said to have counted the seals of his Mediterranean haunts in fives and then to have lain down among them like a shepherd amid his flock. But when one looks over a modern fur-seal rookery with its myriads of active animals, some in the sea and others out and all in commotion and confusion, an estimate of the assemblage, not to

FIG. 15. BRANDED COW PROBABLY TWELVE YEARS OLD. Kitovi Rookery, August 23, 1914.

say a close enumeration, seems impossible. And yet with a little care and good management an enumeration of at least certain elements in the herd can be carried through with considerable accuracy.

At the height of the season, that is, about the middle of July, it is possible to walk along the upper edge of the beaches on which the rookeries are situated and count with fair certainty the bulls with their surrounding harems. At this stage of the breeding activities all the bulls have long since arrived and none have begun to depart,

FIG. 16. COW AND PUP. Kitovi Rookery, August 25, 1914.

hence the conditions are favorable for a census. The bulls themselves, because of their size, are conspicuous creatures and even on very rocky beaches it is almost impossible to overlook them. In a few places, such as on Reef Rookery and especially on Vostochni Rookery under Hutchinson Hill, the harems instead of being strung along the beach are massed in considerable numbers and here the counting of the bulls was not easy, but on almost all other parts of the rookeries the counting of the bulls could be carried out with as much ease and accuracy as the counting of lamp posts or telegraph poles along a street. In this way a close count, accurate within very few per cent., can be made of the breeding bulls.

Toward the end of July the bulls begin to lose their ferocity and some of them even desert the rookeries for the open sea. At this time the majority of them can be driven at least temporarily into the water and with them all the cows. As a result the only members of the herd left on the beach are the pups. These do not naturally take to the water till after the first week in August and therefore at this season they may be counted, after temporarily clearing the beach of the rest of the herd (Fig. 24). In counting these active little creatures operations are begun at one end of a rookery. The pups are assembled in small groups or pods, and pod by pod is driven off in a thin line first on to the unoccupied beach and then, as the count proceeds over the rookery, on to that part freed of pups by the earlier count. The pups string out and run at a mild pace and may be counted as a miniature flock of sheep would be counted. After the live pups have been counted the beach is examined for dead ones and the number thus found is added to the number of living pups to give the total pup count.

This enumeration is also an accurate one, though not so accurate as that of the bulls. Pups may hide among the rocks and thus be omitted, but, aside from omissions of this kind, the count can be made a close one.

The cows, as already indicated, are coming and going between the rookeries and the sea almost continuously and therefore can not be counted with accuracy. The fact, however, that cows are known to produce only one pup each in a season allows a minimum estimate of the breeding cows to be made, for there must have been on the beaches in a given season at least as many cows as there were pups born. In this way the least number of breeding cows for a given year can be accurately inferred.

Rough counts can be made of the idle bulls, that is, of those bulls that have failed to establish harems and that spend their time on the outskirts of the breeding areas attempting to gather a few of the late

FIG. 17. SLEEPING COW AND PUP. Kitovi Rookery, August 23, 1914.

cows about them. These animals move about more or less and can not therefore be enumerated closely.

Finally the bachelors with their roving dispositions can not be dealt with except in the form of roughest estimates, upon which only slight weight can be placed. The fact that they are known to migrate from one island to the other in the course of the season shows that many may be at sea at a given time and that therefore any count of those on land can not be relied upon to represent their total number. This element of the herd is the only considerable one that can not be dealt with in any accurate way so far as enumeration is concerned.

In following the condition of the herd, the count of the new-born pups is of first importance, though the number of harems formed is also of great significance. The pups were first actually counted in the season of 1912, when somewhat fewer than 82,000 were noted. In 1913 over 92,000 were recorded. These two enumerations, which entailed an almost incredible amount of work, were made by Mr. George A. Clark, whose long services in connection with the Pribilof seal herds are well known. The enumeration of 1914 was made by an international party of investigators consisting of Mr. James M. Macoun and Mr. B. W. Harmon, representing Great Britain; Dr. T. Kitahara, representing Japan, and Mr. Wilfred H. Osgood, Mr. Edward A. Preble, and the author, representing the United States. The number of pup seals found by this party for 1914 was a little over 93,000, a slight increase only over the number of the preceding year. In the summers of 1915 and of 1916 the enumerations were made by one of the island officials, Mr. G. Dallas Hanna, with the result that increasing totals of new-born pups, namely, over 103,000 for 1915 and about 117,000 for 1916, have been reported. Not only has the total births of pups increased year by year, but the number of breeding

FIG. 18. COW NURSING PUP. Tolstoi Rookery, August 25, 1914.

FIG. 19. NEWBORN PUP WITH PLACENTA STILL ATTACHED. Tolstoi Rookery, June 25, 1914.

bulls with their harems has also begun to move forward. In 1912 this number was 1,358, in 1913 it was 1,403, in 1914 1,559, in 1915 2,251, and in 1916 3,500. The average harem, which represents the average number of cows that must be served by a bull, has shown during this period a favorable decrease. In 1912 it was 60.4; in 1913 65.8; in 1914 59.3; in 1915 45.5, and in 1916 36.3. Thus in all respects the fur-seal herd under the new conditions shows all the signs of rapid recuperation. Its total size, for reasons already stated, can not be given with accuracy, but it is not unlikely that at present it contains not far from a third of a million of individuals. This number is far short of the two to six millions that it was supposed to contain when it was transferred from Russia to the United States. But whether these early estimates were correct or not can not be known and all that can be said at present is that, so far as well-established numbers are concerned, the tide has changed and in place of an unfavorable decrease a period of profitable increase and sound growth is well established.

The present law concerning the management of the Pribilof fur-seals prohibits the killing of what under ordinary circumstances would be the killable male stock, except in so far as it is needed as food for the natives. As a result of this law only a few thousand seals are killed annually and this small number will remain the number killed till the resumption of activities on a commercial scale after the season of 1917. Moreover the law prescribes that on the resumption of these activities an annual reserve of not fewer than five thousand three-year-old males for breeding purposes be made until 1926 inclusive.

FIG. 20. PUPS. Gorbatch Rookery, August 19, 1914.

The scheme of management thus outlined is neither for the advantage of the fur-seals nor for that of the government. The fur-seals, like other mammals, produce about equal numbers of males and females. Close counts show that there are one or two per cent. more males than

FIG. 21. BACHELORS "HAULED OUT" ON TOLSTOI BEACH, late in August, 1914.

females, but the difference is so slight that equality may be assumed. When, however, the animals arrive at the breeding age one male, as has already been shown, may have over a hundred females in his harem and though this number must be unduly large, it is generally believed that an average harem of thirty to forty cows is in no sense excessive. If the sexes are produced in approximately equal numbers and yet on the breeding ground under the best of circumstances one male serves thirty to forty females, it must follow that many males play no part in the breeding activities of the herd. These in fact are the so-called idle bulls and their number is in a way a measure of this maladjustment. They are sources of disturbance to the breeding individuals and they represent material that should have been killed when their pelts were in their most marketable state, that is, three years old. The most obvious course therefore to be pursued so far as the male of the herd is concerned is to retain at the most marketable age a certain proportion, not a fixed number as the present law prescribes, for breeding purposes and kill all others. If the breeding life of males and females was of the same length and these animals were associated in the proportion of one male to forty females, the reservation of one male in forty at the three-year-old stage would just supply the requisite number of breeding bulls. But the bulls breed only over some six or seven years, whereas the cows are sexually active for almost twice that period. Hence the male reserve should be at least two in forty, or five per cent. The recent suggestion, therefore, that the male reserve should be eight per cent. of the three-year-old bachelors is well on the side of conservatism. Such a solution of the question is very much more in line with

the actual needs of the case than the prescription of a definite number of reserved males as is done by the present law. The system suggested has the advantage of applying successfully to a herd of any size be it one of thousands of individuals or millions.

The practical application of such a reserving system is relatively simple. The reserve first of all should be made in seals of one age, the most marketable so far as their skins are concerned, namely, the three-year-olds. In the drives it has been demonstrated that the native killers can pick out individuals of this age with almost perfect certainty. All that it is necessary to do in making this reserve is to mark eight per cent. of the three-year-old seals in a given drive by cropping the hair on one side of their heads with ordinary sheep shears and then ignoring such marked individuals in all future drives. Such seals are easily recognizable throughout the rest of the season and on their return the next year they have automatically passed on to the four-year class and are thus preserved as breeders.

The only objection to this system that has been raised is that it assumes that a better proportion of the sexes for breeding purposes can be worked out by man than has been established by nature. That such an improvement has already been successfully practised by man is well demonstrated in the common barnyard fowl. This bird both in its wild state and in its domestic condition produces about equal numbers of males and females, yet in its breeding habits one cock serves successfully a number of hens. It is as preposterous to claim that the

FIG. 22. ROVING BACHELORS. Kitovi Rookery, August 23, 1914.

FIG. 23. STAMPEDE OF BACHELORS AT TOLSTOI BEACH, August, 1914.

natal proportions of the sexes of the fur-seals can not be readjusted advantageously by man as it would be to maintain that there must be one cock for each hen in the barnyard for the reason that nature has produced the two sexes in equal numbers. The elimination of a reasonable proportion of the male fur-seals from the herd can have no other effect than to reduce somewhat the daily conflicts between the members of this sex and is certainly a step in the direction of increased welfare for the herd as a whole.

From the standpoint of the government such a proportional killing of three-year-old seals is also advantageous, for it would increase considerably the present supply of marketable seal skins and not only not endanger the herd but, as already indicated, put it in a more favorable condition. The increase of revenue thus brought about is estimated in the hundreds of thousands of dollars annually, sums which under the

FIG. 24. COUNTING PUPS ON GORBATCH ROOKERY, July 30, 1914.

present law are slipping through the fingers of the government. Since the fur-seal herd of the Pribilofs contains at present probably not far from a third of a million of animals and is therefore nowhere near extinction, and since the breeding habits of these seals are such as to call forth a steady increase of useless males, it seems only reasonable that a law that gives these males undue protection should be revised, whereby a safe proportional killing of them should be permitted. In this way the herd could be rendered more stable and the government would receive a greatly increased income which at present is being dissipated in the open Pacific. In other words, the Pribilof fur-seal herd is not only in active process of restoration but a reasonable form of commercial killing should have been resumed several years ago.

SHISHALDIN AND ISANOTSKI VOLCANOES, NEAR UNIMAK PASS.

THE SCIENTIFIC AND ADMINISTRATIVE ACHIEVEMENT OF THE MEDICAL CORPS OF THE UNITED STATES ARMY

By Lieutenant Colonel CHAMPE C. McCULLOCH, Jr., U. S. Army,

LIBRARIAN, SURGEON GENERAL'S OFFICE, WASHINGTON, D. C.

WHEN the history of the present European war comes to be written, it will be found that the part played in the great world struggle by the medical officers of the different armies engaged has been in every way as important as the achievements of the line. Not only has the mortality of the army surgeons in the different battles been fully as high as that of the infantry, but the military administrators have been compelled to admit, reluctantly in some cases, that the medical profession has been their mainstay in the matter of evacuating the wounded from the battlefields and in sending a majority of the wounded back to field service in an incredibly short space of time. In the past, the status of the army surgeon was as dubious as that of the rest of his professional brethren. In seventeenth and eighteenth century Prussia, he was still a barber surgeon who shaved the officers of the line, and only a few years ago, a British medical officer who had been rewarded for heroism in the field was contemptuously dubbed "a brave civilian" by the commander of the British army, a man who never saw a battle. Modern wars have changed all that. The commanding officer of to-day, who is wise, instinctively acts according to the sentiment of General Winfield Scott: "I am in the habit, myself, when on duty with troops, of paying great deference, and even of yielding my opinion, on matters deeply affecting health and life, to the advice of my medical staff." "War," said the Russian army surgeon Pirogoff, "is a traumatic epidemic. Not medicine, but administration plays the leading part in the aid of the sick and wounded in the scenes of war." The work of Pasteur and Lister has made the first part of this aphorism negligible. Thanks to antiseptic surgery, we no longer fear the traumatic infectious diseases in the field or base hospitals. But the second part of Pirogoff's dictum reveals the wonderful prescience of the gifted Russian. Medicine is now slowly coming into its own. The army medical officer of to-day must not only be a trained scientist but a capable administrator. In other words, his duties in the zone of advance, the line of communications, and the interior, are in every respect as onerous and exacting as those of the line or engineer officer, and the story of his accomplishment, in the present war, will, when told, make a brilliant record. At the present moment, it seems fitting and proper

to draw public attention to the scientific and administrative achievement of the Medical Corps of our Army in the past. In preparing this record, I have been much indebted to Dr. Fielding H. Garrison (Surgeon General's Library), who has summarized the recent work of the Medical Department of the Army in his "History of Medicine" (1913, 1917).[1]

During the colonial period, the status of medicine on this continent was of the most provincial character, its practitioners being sometimes ministers of the Gospel, oftener men who had got their training with physicians under indentures of apprenticeship, with no medical degree whatever, self-trained mid-wives for obstetric cases, back-woods saw-bones who had acquired their knowledge of surgery in the most rough and ready fashion, and a few settlers who had acquired a legitimate education in Europe, with the still more favored few whose parents were able to give their sons a proper medical education at some European university. The title "doctor" was not even employed in the Colonies before 1769. Medical legislation in the several states was mainly centered upon the regulation of physicians' fees, and with the exception of the Acts of Massachusetts in 1649 and 1699, and of New York in 1665, little of it was restrictive, in the sense of excluding the incompetent, or of application to the prevention of infectious diseases.[2]

With the Revolutionary War, which has been described as "the making of medicine in this country," things took a new turn. Morgan, Shippen and Rush, the three Surgeons General who did most for the medical service of the Army in this War, were also the three greatest American physicians of the period. John Morgan (1735–89), who was appointed Director General and Physician in Chief of the American Army in 1775, and William Shippen (1736–1808), who succeeded him in 1777, were the leading pioneers in advancing medical education in this country, having collaborated as founders of the Medical Department of the University of Pennsylvania in 1765. Benjamin Rush (1736–1808), who was appointed Surgeon General of the Hospital in the Middle Department in 1777, transferring to the position of Physician General twelve weeks later, was regarded, both in Europe and America, as the greatest American physician of the period, being somewhat effusively styled the American Sydenham and the Hippocrates of Pennsylvania. Although he deserted Washington at Valley Forge to join the "Conway Cabal," Rush was the author of a valuable pamphlet on the hygiene of troops (1777), the first American treatise on insanity (1812), and the first contributions made in this country to the then unknown science of anthropology (1774–88). He was perhaps the first physician to describe cholera infantum (1773), the second to describe dengue (1780), and the part he played in fighting the epidemic

[1] Garrison, "Introduction to the History of Medicine," Philadelphia, 1913, 618–620; 2d ed., 1917, 732–736.

[2] *Ibid.*, 2d ed., 1917, 296–298.

of yellow fever in Philadelphia in 1793 is a prominent feature of the history of that city.

The earliest American pharmacopœia to be printed was that prepared for the use of the Continental Army by Dr. William Brown, of Virginia, who succeeded Rush as Physician-General of the Middle Department (1778–80). It was issued from the military hospital at Lititz, Lancaster County, Pa., and appeared anonymously as a Latin booklet of thirty-two pages in 1778. A facsimile of the title-page of the second edition (1781), which bears the name of Brown, may be seen in Dr. Handerson's translation of Baas's "History of Medicine" (p. 820). A unique copy of the rare first edition is on exhibition in the Surgeon General's Library.

James Thacher (1754–1844), who became Assistant Surgeon in 1775, left a remarkable "Military Journal during the American Revolutionary War" (1826), which is an authoritative source of historical information, describing the treason of Arnold, and the capture of André, and giving perhaps the best contemporary appreciation of the character of Washington. Thacher was also the author of the first American work on medical biography (1828), which makes him, in a sense, our first medical historian.[3]

John Jones (1729–91), who had been a surgeon of French troops in the war of 1758 and afterwards rendered worthy service in the Revolution, published a treatise on wounds and fractures in 1775, which was the first surgical work published in this country, and, through its appendix on camp and military hospitals, the first American book on military medicine.

Of the early Surgeons General after the Revolution, James Tilton (1745–1822) introduced the "hut system" during the war, to avoid overcrowding of hospitals, and also published the first American book on medico-military administration (1812). Joseph Lovell (1788–1836), appointed Surgeon General upon the formal organization of the Army Medical Department in 1818, organized the Department and revised its regulations, giving it the form which it retained up to 1861. In 1834, he introduced competitive examinations for admission to the Corps and he abolished the whiskey ration. Thomas Lawson (1795–1861), Surgeon General from 1836 until the outbreak of the Civil War, secured actual military rank without command for the Army Medical Officers in 1847, and, in 1856, enlarged the capacity of his commissioned force by the enlistment of hospital stewards as such.

William Alexander Hammond (1828–1900), Surgeon General during 1862–64, early made his mark as a physiologist by his essay on "The Nutritive Value and Physiological Effects of Albumin, Starch

[3] The first American book on the history of medicine was actually a work of the colonial period, viz., Peter Middleton's "A Medical Discourse, or an Historical Inquiry into the Ancient and Present State of Medicine," New York, 1769.

and Gum when singly and exclusively used as Foods" (1857), which was awarded the prize of the American Medical Association in 1857, gave him a European reputation and secured him the Chair of Anatomy and Physiology in the University of Maryland in 1860. During his war service as Surgeon General, he introduced many reforms and improvements in the medical service, such as the issue of a new and enlarged supply table, the furnishing of suitable hospital clothing to patients, the establishment of a new and complete system of hospital reports, the reorganization of examinations and examining boards for the medical service, and the extensive construction of hospitals built upon the pavilion system. Of Hammond's career as Surgeon General Dr. Weir Mitchell said:

> Whatever else may be thought or said of William A. Hammond, nothing is more sure to me than that he duly saw and grasped a great opportunity; that he served his country as few could have done; that he created the Army Medical Museum; that he saw the need for and advised the creation of the Army Medical School; that he pointed out the men who were to direct the Army Museum and the Army Library. Until the end of his Army career he was the unfailing friend of scientific study, and created special hospitals for diseases of the heart, lungs and neural maladies.

At these hospitals, Acting Assistant Surgeon J. M. Da Costa first described irritable heart in soldiers (1862), and Acting Assistant Surgeons S. Weir Mitchell, George R. Morehouse and William W. Keen made their investigations of gun shot and other injuries of nerves (1864), which have since become classical. Hammond's systematization of medico-military reports led to the "Medical and Surgical History of the War of the Rebellion" (1870–88), which was completed under his administrative successors, Joseph K. Barnes (1864–82), Charles H. Crane (1882–3), Robert Murray (1883–6) and John Moore (1886–90), by Surgeons George A. Otis, Joseph Janvier Woodward, Charles Smart and David L. Huntington. This is a great collection of surgical and medical case histories and pathological reports, in six huge quarto volumes, embellished with splendid plates, a work which soon became known all over the civilized world as the most remarkable contribution to military medicine made up to that time. It received the highest praise from Professor Rudolph Virchow, the greatest of modern pathologists. After his dismissal from the Army, in consequence of his difficulties with Secretary Stanton, Hammond went to New York, where he became a noted authority on nervous diseases and insanity, through his treatises on these subjects, published in 1871 and 1883 respectively. He was the first to describe the neurotic condition known as "athetosis" (1873), and was editor of the *Quarterly Journal of Physiological Medicine and Medical Jurisprudence* (1867–72), the *New York Medical Journal* (1867–9), and the founder and editor of the *Journal of Nervous and Mental Disease* (1867–83).

To Hammond's successor, Joseph K. Barnes (1817–83), Surgeon General during 1864–82, fell the task of disbanding the huge corps of civil physicians serving the army under contract, dismantling and discontinuing the great hospitals, settling outstanding accounts and noncontinuing appropriations, which was carried forward under the direction of his able assistant, Surgeon J. S. Billings. Under Barnes, the exclusive control of general hospitals and hospital camps was vested in the Medical Department, the publication of the Medical and Surgical History of the War was begun, the development of the Army Medical Museum and Library was fostered under the direction of Billings, and the exhaustive Reports upon Barracks and Quarters and Hygiene of the Army, edited by Billings, were published in 1870 and 1875 respectively. Next to the Medical and Surgical History of the War, these were the most important contributions made to military medicine in this period.

Under John Moore (1826–1907), Surgeon General during 1886–90, instruction in first aid was inaugurated in the service in 1886. This was one of the most important steps for the welfare of trooops, in connection with which the first aid books of Dietz, Smart and Pilcher were published and the Hospital Corps of the United States Army was organized by Act of Congress in 1887, resulting in the drill manuals of Pilcher, Heizmann, Hoff, Havard, Woodhull and Dietz. The last volume of the Medical and Surgical History of the War was published in 1888.

Charles Sutherland (1831–95), Surgeon General during 1890–93, gave the Medical Department a new field equipment, gave the post hospitals sole authority for the issuance of surgical supplies and furthered the development of the Hospital Corps.

George Miller Sternberg (1838–1915), Surgeon General 1893–1902, was the first to isolate the bacillus of croupous pneumonia (1880), published the first manual (1893) and text-book (1896) of bacteriology, and important treatises on immunity (1895), disinfection (1900) and infection (1903). He did important scientific work on yellow fever, and, under his administration, the agent of transmission of yellow fever was discovered by Major Walter Reed in 1901, and the sanitary regeneration of Havana was accomplished by Major William C. Gorgas, shortly after. During the Spanish-American War, General Sternberg met all the increased demands upon his corps with efficiency, in the face of legislative embarrassment and administrative obstacles, establishing a corps of female nurses for service in permanent hospitals, increasing the medical staff by officers selected from the Association of Military Surgeons, and afterwards supervising the organization of medical service in our new tropical possessions. He founded the Army Medical School, established laboratories of bacteriology and hygiene in connection with the Army Medical Museum, secured the assignment of medical

officers to stations in large cities affording unusual advantages for advanced medical studies, established a sanatorium at Fort Bayard for the treatment of pulmonary tuberculosis, created a special surgical hospital at Washington Barracks, and organized additional schools for the Hospital Corps.

Robert Maitland O'Reilly (1845–1912), Surgeon General during 1902–9, was an active member of boards for selecting camp sites during the Spanish-American War and the cleaning up of Havana after it. Upon assuming the office of Surgeon General, he immediately set himself to the task of carrying out the recommendations made by the Dodge Commission for the improvement of the Army Medical Corps, as the result of which it is now able to equip its hospitals and field units more rapidly than they can be organized and their personnel brought together. He created the Medical Reserve Corps of the Army for the expansion of its medical service in time of war, in which many distinguished physicians and surgeons of the country are now enrolled. He organized and presided over the Board recommending the adoption of preventive vaccination against typhoid fever in the army, and it was due to his good offices that Professor Russell H. Chittenden, of Yale University, was able to use a squad of Hospital Corps men in carrying out his important experiments upon the physiological economy of nutrition, the practical object in view being to ascertain the best scheme of rations for troops under modern conditions.

George H. Torney (1850–1913), Surgeon General during 1909–1913, instituted compulsory vaccination against typhoid fever among United States troops, also the measures for the control of venereal diseases in the Army and of beri beri in the Philippines. All these have been most effective. During the mobilization of United States troops on the Mexican border in 1912, Major Frederick F. Russell vaccinated the entire body, some 20,000 men, against typhoid fever, and by further vaccinations throughout the army has brought down the morbidity and mortality record of this disease to practically zero. Beri beri has practically disappeared among the rice eating native troops in the Philippine Islands, largely through the investigations of Captain Edward B. Vedder. At the outbreak of the Spanish-American War, in May 1898, Torney was ordered to equip and command the United States Army hospital ship *Relief*, and, under his direction, transportation of the sick and wounded from Cuba and Porto Rico to the United States was accomplished in the most efficient way. When the Mexican mobilization took place, the medical equipment of the manœuver division included a complete modern sanitary organization, with full quota of field hospitals and ambulance companies in addition to the regimental sanitary service. General Torney also advocated the bills which reorganized the Dental Corps of the Army and the Army Nurse Corps. At the

time of the San Francisco earthquake and fire, General Torney was commanding officer of the General Hospital at the Presidio, and upon him devolved the general management of medical relief and sanitation in connection with the disaster. Of his splendid work on this trying occasion, the San Francisco *Examiner* says:

By the provisions of General Orders No. 37, General Funston performed, perhaps, the most important act of his administration of the affairs of the city of San Francisco; for by this order he placed the sanitary affairs of the city under the one officer of the United States Army who is the most competent to care for the greatest problem now confronting its courageous citizens. As commanding officer of the General Hospital at the Presidio, Colonel George H. Torney has already made a name for himself which will always live in the memory of San Francisco. Who will ever forget the work he has done for humanity at that magnificent institution? When every other hospital in the city was threatened with destruction and patients were being carried out as fast as willing hands could care for them, Colonel Torney was receiving them at the General Hospital, as fast as automobiles, carriages, wagons and ambulances could carry them to the Presidio. He was one of the first to realize the magnitude of the calamity and without waiting for orders from any one, he notified the city authorities that the General Hospital was at the disposal of its wounded and dying. It is indeed refreshing to see an officer act so quickly and courageously without the usual amount of red tape.

William Crawford Gorgas (1854–), of Mobile, Alabama, Surgeon General since January 16, 1914, was chief sanitary officer of Havana during 1898–1902, and chief sanitary officer of the Panama Canal from March 1, 1904. His brilliant work in ridding Havana and the isthmus of yellow fever and other dangerous infections will be considered below.

It now remains to describe the scientific work done by individual medical officers of the army, apart from the Surgeon Generalcy.

Before the days of Reed and Gorgas, perhaps the most distinguished name of the Medical Corps in the annals of science is that of William Beaumont (1785–1853), who was the pioneer of experimental physiology in this country and who made the most important contribution to the physiology of digestion for centuries. In June, 1822, Surgeon Beaumont, then stationed at the distant outpost of Fort Mackinac, Michigan, came in contact with a young French Canadian, Alexis Saint Martin, who had sustained a severe accidental gunshot wound of the chest and abdomen. Under Beaumont's treatment the wound was partially healed at the end of about ten months, with the exception of a permanent opening in the stomach or gastric fistula. As Saint Martin was declared a "common pauper" by the civil authorities of the county, Beaumont took care of him in his own house, dressing his wounds daily for nearly two years, and during this time, he became impressed with the fact that the permanent gastric fistula of his patient could be utilized for physiological experimentation. In May, 1825, he began his experiments, a long series of patient researches covering eight years, and although Saint Martin frequently deserted him, and had to be

tracked and brought to the different army posts at Beaumont's own expense, on one occasion nearly two thousand miles, his perseverance was rewarded when he published his "Experiments and Observations on the Gastric Juice, and the Physiology of Digestion" (Plattsburgh, N. Y., 1833), which soon became recognized as one of the great classics of physiology. Beaumont was the first to describe the movements of the stomach, the secretion of its juices and the phenomena of gastric inflammation, as seen by the naked eye, his results anticipating much modern work; and he made studies of the effect of the gastric juice upon different foods which are the foundation of modern dietetic scales. Of his work, Sir William Osler said, in an address made at St. Louis on October 4, 1902:

> You do well, citizens of St. Louis and members of our profession, to cherish the memory of William Beaumont. Alive you honored and rewarded him, and there is no reproach against you of merit neglected and talents unrecognized. The profession of the northern part of the state of Michigan has honored itself in erecting a monument to his memory, near the scene of his disinterested labors in the cause of humanity and science. His name is linked with one of your educational institutions, and joined with that of a distinguished laborer in another field of practise. But he has a far higher honor than any you can give him here—the honor that can only come when the man and the opportunity meet and match. Beaumont is the pioneer physiologist of this country, the first to make an important and enduring contribution to this science. His work remains a model of patient, persevering investigation, experiment and research, and the highest praise we can give him is to say that he lived up to and fulfilled the ideals with which he set out and which he expressed when he said: "Truth, like beauty, when 'unadorned, is adorned the most,' and, in prosecuting these experiments and inquiries, I believe I have been guided by its light."

During Surgeon General Barnes's administration, following the Civil War, his medical staff consisted of a brilliant group of officers who did some remarkable scientific work. Of these, Joseph Janvier Woodward (1833–84) was an expert pathologist, and the best worker of his time in photo-micrography, or the photographic enlargement of pictures of microscopic objects, in which he was a pioneer. In this work he was assisted by Edward Curtis (1838–), who, in 1869, collaborated with Billings in investigating the supposed microscopic organisms causing diseases of cattle. General Alfred A. Woodhull (1837–) was the first in this country to employ the British Indian method of giving large doses of ipecac in dysentery (1875–6), catalogued the specimens in the surgical section of the Army Medical Museum (1866), and has written valuable manuals on litter drill for Hospital Corps men (1899) and military hygiene for officers of the line (1898). He also made an important report on the Medical Department of the British Army in 1891, and is the author of suggestive studies on the causation of yellow fever (1877–80) and the sanitary relations of military sites (1894). George A. Otis (1830–81) collaborated with Woodward, Charles Smart

and David L. Huntington in the Medical and Surgical History of the War, of which his surgical reports on amputations at the hip joint (1867) and excisions of the head of the femur for gunshot injury (1869) won the admiration of army surgeons all over the world. The most remarkable member of the group was John Shaw Billings (1838–1913), who, during the war, was the first surgeon in this country to attempt the rare operation of excision of the ankle joint (January 6, 1862), with complete recovery of his patient. To his enterprise, perseverance and ability was due the building up of the Surgeon General's Library, which is now the second largest, and through its unrivaled collection of periodicals, the best medical library for actual use in the world. The Index Catalogue of this library, begun by Billings in 1880, with the assistance of his faithful coadjutor, Dr. Robert Fletcher, and continued to date, places the entire literature of medicine, including the contents of periodicals, at the physician's ready disposal, and is used by scientific workers and libraries everywhere. In many important respects it is the most important and extensive bibliography in existence, the first and second series now numbering thirty-seven large quarto volumes (1880–1916). The first volume of a third series (1917) is already in process of publication. Billings was also the designer of the Johns Hopkins and other modern hospitals, supervised the vital and medical statistics of the tenth, eleventh and twelfth censuses, was the leading American authority in his day on military medicine, public hygiene and sanitary engineering, and wrote what is regarded as the best history of surgery in the English language. Upon his retirement from active service in the army, he planned and organized the New York Public Library and its many branch establishments. The many other achievements of this tireless worker would fill a volume.

Dr. Robert Fletcher (1823–1912), after an honorable career in the Civil War as army surgeon, became Dr. Billings's associate in the Surgeon General's Library, edited the *Index Medicus* (1879–1911), was author of the treatise on anthropometry in the statistical volumes of the Provost Marshall's Bureau (1875), of a valuable monograph on "Prehistoric Trephining" (1882), and made many original contributions to anthropology and medical folk-lore.

Dr. H. C. Yarrow, who was surgeon of the Fifth Pennsylvania Cavalry during the Civil War, was acting assistant surgeon in the United States Army for thirty years, during which time he served on exploring expeditions and in the Surgeon General's Library, and made worthy contributions to herpetology, ichthyology and anthropology, notably an extensive study of the mortuary customs of the North American Indians (1880–81).

Jonathan Lettermann (1824–72), of Canonsburg, Pa., was Medical Director of the Army of the Potomac (1862–3), and during this period, brought order out of chaos by his wonderful reorganization of the med-

ical service in the field. He devised a new ambulance system for evacuating the wounded from the field, perfected the present system of supplying the army with medicines and medical material, inaugurated the system of field hospitals for the immediate relief of the wounded and their speedy return to the firing line, improved the blank forms for medico-military reports and did much to combat camp diseases. His record has only been equalled in the past by that of the immortal Larrey, of Napoleon's army.[4]

In accordance with the liberal policies of General Sternberg's administration, Major Walter Reed (1851–1902) was sent to pursue advanced studies in pathology and bacteriology under Professor Welch at the Johns Hopkins Hospital, and in Welch's laboratory made an important investigation of the lymphoid nodules of the liver in typhoid fever (1895). In 1900, Reed was detailed as the head of a board, which included James Carroll, Aristide Agramonte and Jesse W. Lazear, to study yellow fever in Cuba. At this time, it was commonly supposed that the disease was caused by a special micro-organism, the Bacillus icteroides of Sanarelli. Reed subjected this theory of causation to severe tests and soon disproved it. Meanwhile, it had been assumed by J. C. Nott in 1848 and by Carlos Finlay in 1881–6 that mosquitoes are agents in the transmission of yellow fever, and this theory had already been proved to be true in the case of malarial fever by the experimental demonstrations of Ross and others. Reed now proceeded to put this theory to the test, and, with his associates, was able to demonstrate in the most rigorous manner, that yellow fever is transmitted by a special variety of mosquito, the *Stegomyia fasciata,* and not as had hitherto been supposed, by contagion from clothing and bedding or through infection by water, sewage, or other substances accidentally taken into the mouth. To prove this, a number of non-immune persons voluntarily subjected themselves to the bites of mosquitoes which had fed upon known yellow fever patients, or to injections of blood or filtered blood-serum from such patients. Twenty-two cases of experimental yellow fever were thus produced, while seven enlisted men boldly slept in infected bedding without acquiring the disease. Carroll was the first to submit to mosquito inoculation, and sustained an attack of yellow fever from which he recovered. Lazear, who had been accidentally bitten by a yellow fever mosquito, died from the disease. Reed's results were soon confirmed by other observers in Mexico, South America and elsewhere, and the fact that yellow fever is transmitted by a special variety of mosquito alone gave the sanitarian the proper means for pre-

[4] For Lettermann's work, see his "Recollections of the Army of the Potomac" (New York, 1866); also *Jour. Mil. Service Inst.*, Governor's Island, N. Y. H., 1883, IV., 250–287 (B. A. Clements); *Military Surgeon*, Chicago, 1913, XXXII., 221–249 (L. C. Duncan); *Johns Hopkins Hosp. Bull.*, Balt., 1916, XXVII., 243–247 (J. T. Smith).

venting its occurrence. Of this discovery Professor Welch said: "I am in a position to know that the credit for the original ideas embodied in this work belongs wholly to Major Reed." General Wood, who had furnished Reed with the authority and the financial means to carry on his experiments, said:

> I know of no other man on this side of the world who has done so much for humanity as Dr. Reed. His discovery results in the saving of more lives annually than were lost in the Cuban War, and saves the commercial interests of the world a greater financial loss each year than the cost of the Cuban War. He came to Cuba at a time when one third of the officers of my staff died of yellow fever, and we were discouraged at the failure of our efforts to control the disease. In the months when the disease was ordinarily worst the disease was checked and driven from Havana. That was the first time in nearly two hundred years that the city had been rid of it. The value of his discovery can not be appreciated by persons who are not familiar with tropical countries. Hereafter it will never be possible for yellow fever to gain such headway that quarantine will exist from the mouth of the Potomac to the mouth of the Rio Grande. Future generations will appreciate fully the value of Dr. Reed's services.

President Eliot, in conferring an honorary degree upon Reed at Harvard, expressed himself in the same terms.

The task of eradicating yellow fever at Havana fell to Major William C. Gorgas, who became chief sanitary officer of the city in February, 1901, and who put Reed's hypothesis to practical use by the simple process of screening yellow fever patients and habitations, and by destroying the mosquitoes themselves. Inside of three months, Havana was freed from the disease for the first time in 150 years. On March 1, 1904, Colonel Gorgas became chief sanitary officer of the Panama Canal and on March 4, 1907, a member of the Isthmian Canal Commission. When the French began to work on the canal in 1880, Panama was one of the plague spots of the universe. Colonel Gorgas proceeded to take measures for the sanitation of the isthmus on the widest scale, as it was necessary to make the isthmus free from disease before commencing operations upon the canal. The towns of Colon and Panama were in the poorest sanitary condition, with no proper water supply, drainage or sewage systems, unpaved streets without proper gutters, houses sometimes surrounded by water at high tide, infested with rats, the transmitters of bubonic plague, and, in the outlying country, mangrove swamps and areas covered with dense jungle vegetation, underbrush and matted vines, which are a favorite habitat of mosquitoes. Under the French occupation, it was a by-word that every tile laid cost a life. Hand in hand with such prophylactic measures as destroying mosquitoes by spraying with dripping oil upon the surface of still or running bodies of water, making habitations and hospitals mosquito-proof by covering verandas, doorways and windows with woven wire screens, isolating all suspected cases of malarial or yellow fever, administering prophylactic doses of quinine in malarial patients, it was necessary to

clear up and remove all outlying underbrush, a matter of great expense, to pave and gutter every street, to construct mosquito-proof houses, a complete installation for municipal water supply and sewage disposal by piping, to provide every house with modern closets with a pipe-borne sewage system, to fill and obliterate swamps and stagnant pools, to destroy rats as well as unhealthy houses occupied by them, and to disinfect and fumigate the houses contaminated with dangerous diseases. In 1881–9, the French lost 22,189 laborers by death, in other words a death rate of 240 per thousand per year. One station on the old Panama railroad was called Matachin, from the Spanish words *mata*, "killed," and *chin*, "Chinaman," because 1,000 imported Chinamen in houses at this point died off in six months, as also 1,000 negroes from the West Coast of Africa. When the United States took charge of Panama in 1904, the death rate was 40 per 1,000, a yellow fever epidemic raging there from July, 1904, to December, 1905. In less than a year, Gorgas had eradicated it entirely and there has not been a single case since May, 1906. In that year, the admissions to hospitals for malaria were at the rate of 800 per 1,000 workers; by 1913, this rate had been reduced to 76 per 1,000. The death rate from all causes among the workers was about 41 per 1,000; in 1913, it was 8 per 1,000. The general death rate among the total population is now 22–23 per 1,000. The total cost of sanitation has been less than one per cent. of the total appropriation for all purposes. General Gorgas says:

> When the canal shall have been finished it can be shown that sanitation cost about $365,000 per year. For a population of 150,000 this means an expenditure of about one cent *per caput* per day, and this sum is well within the means of any tropical country.

Elsewhere he says:

> I do not believe that posterity will consider the commercial and physical success of the Canal the greatest good it has conferred upon mankind. I hope that as time passes our descendants will see that the greatest good the construction of the Canal has brought was the opportunity it gave for demonstrating that the white man could live and work in the tropics, and maintain his health at as high a point as he can, doing the same work, in the temperate zone. That this has been demonstrated none can justly gainsay.

In Trinidad, British Guinea, and in all tropical posesssions now inhabited by the white races, the preventive measures used by Ross at Ismailia and by Gorgas at Panama are beginning to be employed. In December, 1913, Colonel Gorgas, at the invitation of the Chamber of Mines of Johannesburg, South Africa, made a scientific inspection to investigate the cause of the high death rate from pneumonia among the native laborers working in the mines of the Rand, a force of some 200,000 negroes. The death rate was 71.7 per 1,000 in 1903 and 26.84 in 1912. Gorgas made a careful survey of existing conditions, concluding that malarial fever, tuberculosis and miners' phthisis also play

an important part in the high rate of mortality and made a number of valuable suggestions for preventing these diseases, such as increasing the floor space of barrack habitations to about fifty feet, the housing of families in huts, the establishment of a central sanitary bureau, the introduction of proper sewerage and water supply, the destruction of flies and other details.

On returning to the United States to assume the office of Surgeon General, General Gorgas was banqueted in London on March 23, 1914, and received the degree of Doctor of Science at the University of Oxford on the same day. Upon presenting him for the degree, Mr. A. D. Godley, the public orator of the university, said:

> Those are most to be honored by us who have increased knowledge and thereby promoted the welfare of the world. Such are many students of medicine: it is a fine thing to have the scientific knowledge which can cure disease; but theirs is a still finer if more dangerous task who can extirpate the causes from which disease springs. It is such men who destroy the seeds of death which are bred in swamps, risking their health and even their lives to serve their fellows. These heroes are a modern realization of the legend of Heracles, the cleanser of foul places and the enemy of evil beasts.
>
> The eminent American whom you see to-day has, like many of his countrymen, fought in the forefront of the battle. His achievements are too numerous for me to relate in detail. Suffice it to say that it is he who cleansed Havana; it is he who put fever and pestilence to flight in the Isthmus of Panama and made possible the long-thwarted construction of the great inter-oceanic waterway; it is he who has recently improved the sanitary conditions of the South African mines. He purified foul air; he waged war on the myriad swarms of death disseminating mosquitoes. The result has been an amelioration of the conditions of human life in plague haunted districts, where once "in silent fear the helpless healer stood," and it is now possible to live in comfort and to work with advantage. There can be no better example of those "whose skill hath served the human lot to raise, and won a name that endless ages praise."

Upon admitting General Gorgas to the degree, the Acting Vice Chancellor, Dr. T. H. Warren, addressed him as: "Preeminently distinguished, sagacious, health-bringing, the modern Machaon of the American Army, whom indeed I should wish to salute not only in Latin prose but also in Greek verse thus:

> Hail Router of the Plague of Flies! Hail Isthmian Conqueror true!
> Gorgas, to that wise Goddess dear, the Gorgon death who slew!

In 1916, General Gorgas spent several months in South America in making a preliminary survey, for the Rockefeller Foundation, of existing endemic foci of yellow fever in that continent.

At the close of the Spanish American War, it was found that more than 20,000 cases of typhoid fever had occurred among our troops encamped within the limits of the United States between May and September, 1898. Major Walter Reed was delegated as president of a board consisting of Majors Victor C. Vaughan and Edward O. Shakespeare, United States Volunteers, to investigate the cause and possible

means of prevention of this plague of encamped armies. After a most careful investigation, it was found that every regiment constituting the First, Second, Third, Fourth, Fifth and Seventh Army Corps developed typhoid fever, that more than ninety per cent. of the volunteer regiments developed the disease within eight weeks after going into camp, that typhoid fever is disseminated by the transference of the excretions of an infected individual to the alimentary canals of others, that camp pollution was a more prominent causal agent in this instance than contaminated water supply, and that the disease was mainly disseminated by flies, on the clothing of human carriers, by dust, and by infected bedding and tentage. Wholesale disinfection of excreta and all other possible sources of infection was recommended, also sterilization of water supply, raising of soldiers' beds from the ground, removal of troops from infected sites and proper policing of new sites, liberal spacing between tents and the men inside them and more correct diagnosis of typhoid by army surgeons, only about one half the actual number of typhoid cases being correctly diagnosed in this instance. In this epidemic, the deaths from typhoid were 86.24 of the total deaths, the morbidity from typhoid was 192.65 per 1,000 of mean strength, the mortality was 14.63 per 1,000 mean strength, in a group of soldiers numbering 107,973 men. The investigations of Reed, Vaughan and Shakespeare attracted wide attention and their recommendations became of great use to army surgeons. We may contrast the figures given by Reed with the results obtained by Major Frederick F. Russell during the mobilization of United States troops on the Mexican border in 1912. Prior to this date, preventive inoculation against typhoid by means of a specific vaccine had been made practicable and successful by Chantemesse and Widal in France, Sir Almroth Wright in England, and others, and in 1909, Major Russell began the gigantic experiment of vaccinating the United States Army against typhoid. From a morbidity of 173 cases in 1909, he was able to bring his statistics down to 9 cases of the disease with one fatality in 1912. At present the army is absolutely free from typhoid. During the Mexican mobilization, Russell vaccinated some 20,000 men against typhoid, the only case occurring in camp being that of a non-vaccinated teamster. As typhoid fever has the reputation of destroying more men in war time than the enemies' bullets, the significance of these statistics needs no further elucidation.

During the American occupation of Porto Rico, it was found that smallpox was endemic there, as it has been in all Spanish American countries. It was said that the people thought little more of smallpox than of an attack of prickly heat. In December, 1898, the incidence of the disease assumed such proportions in the island that an epidemic was threatened. In January, 1899, the reports of the post surgeons for

November and December showed that 3,000 cases had been noted in this short period. Thereupon, by order of Governor General Davis, the entire population of the island, including infants under six months of age, was vaccinated under the direction of the Chief Surgeon of the Division, Major John Van R. Hoff. As an experience of six months had shown that all virus from the United States lost its virility on reaching the island, a vaccine farm was established at Coamo Springs, under the successive commands of Major Azel Ames, U.S.V., and Captain F. P. Reynolds, U.S.A. Cattle were abundant, being obtainable at one dollar per head, and with the cooperation of the native physicians and the local alcaldes, the work was soon accomplished. In spite of the difference in language and customs of the people, the constantly recurring rains which frequently made the mountain streams impassable, the lack of hotels and other accommodations in the country villages, no less than 800,000 persons were vaccinated in three working months and by October 1899, there was not a single case of smallpox known to either the military or civil authorities. The total cost of ridding the country of the disease was $32,000, or about four cents for each person vaccinated. In like manner, Colonel Hoff stamped out leprosy in the island, by segregating the patients in a leper colony.

In 1900, Captain Bailey K. Ashford discovered the presence of hookworm infection in the island, and shortly afterward, it was found to be very prevalent among the rural population of the southern states of this country by Dr. Charles W. Stiles, of the Public Health Service, who found that the American variety of the specific parasite of the disease is a new species. Captain Ashford has devoted himself to the task of stamping out hookworm infection in Porto Rico, having treated some 300,000 patients in 1903–4, and having reduced the mortality by ninety per cent. He is now engaged in the study of the causation of tropical sprue in South America.

In the Philippines, Captain Charles F. Craig demonstrated that intra-corpuscular conjugation in the parasites of malarial fever is the cause of latency and relapses of the disease, and that there are malaria carriers, that is persons who carry the malarial parasites about with them without being affected by the disease. In 1906, Craig discovered a new parasite connected with the dysenteric infections, the *Paramœba* (now called *Craigia*) *hominis,* and is the author of valuable monographs on the malarial fevers (1901, 1909) and the parasitic amœbæ in man (1911). With Major Percy M. Ashburn, he discovered another parasite, *Microfilaria philippinensis,* in 1906, and demonstrated that the cause of dengue or break bone fever is a filterable virus transmitted by the mosquito *Culex fatigans* (1907).

In the Philippines also, Captain Edward B. Vedder made important investigations of beri beri, a tropical form of neuritis which has been

attributed to a too exclusive diet of highly milled or polished rice. It was found that the disease is what is now termed a "deficiency disease," that is one caused by a diet deficient in certain substances necessary to the physiological economy of the body. This was conclusively proved by Vedder and his associates, after a careful investigation of the pathology of the disease in fowls as well as man. It was shown that beri beri can be eradicated in the native Philippine troops and scouts by a simple change of ration, substituting under-milled for polished rice, that the disease can be experimentally produced in puppies and fowls, and that the administration of an alcoholic extract of rice polishings to infants suffering from beri beri will alleviate some of the symptoms of the disease It is recommended that under-milled rice be substituted for the polished variety as a food staple for the poorer classes wherever possible. All these results have been admirably summed up in Captain Vedder's recent treatise on beri beri (1913) which is the latest and most exhaustive work on the subject. Captain Vedder was also the first to determine that emetine has a specific amœbicidal action in amœbic dysentery (1910–11), which fact was speedily translated into action by Sir Leonard Rogers, and others.

When Ehrlich announced the discovery of his new remedy for syphilis ("606"), Captain Henry J. Nichols of the army collaborated with him in trying out the drug in the early stages of its investigation, and shortly after, Surgeon General Torney issued a circular giving directions for its use in the army. Since then, Captain Nichols has continued his valuable researches on the treatment of syphilis and has investigated the experimental production of the tropical disease "yaws" or frambœsia (1910–11).

Major Eugene R. Whitmore established the Pasteur Institute at Manila (1910), made investigations of rabies and tropical dysentery, and served on the Yellow Fever Commission (South America) in 1916.

In 1911, Drs. E. R. Gentry and T. L. Ferenbaugh discovered that Malta fever is endemic in Southwestern Texas, in connection with the goat ranches, demonstrating these animals to be the agents of its transmission.

Major Weston P. Chamberlain has made important investigations of hookworm infection, diphtheria, Vincent's angina, typhoid fever and beri beri in the Philippines, and collaborated with Captain Vedder in his work on beri beri.

Lieut. Colonel Charles E. Woodruff (1860–1915), retired, late editor of "American Medicine," made highly original investigations on the deleterious effects of tropical light on the blonde races, and has published several volumes, including "The Effects of Tropical Light on White Men" (1905), "The Expansion of Races" (1909) and "Medical Ethnology" (1915) which have had an international circulation and reputation.

Captain Arthur C. Christie is the author of the latest and most up-to-date book on X-ray diagnosis (1913).

The recent treatise of Colonel Louis A. La Garde on gunshot wounds (1914) is, in connection with the present war, the book of the hour. Colonel La Garde was the first to point out that microorganisms are not destroyed, when placed in gun powder or on projectiles, by the act of firing (1892). Up to the time of his first publication on the subject, the idea had prevailed that the heat of ignition in the explosion and that conveyed to the bullet at the time of firing was sufficient to disinfect both, and that powder grains and bullets were made sterile after leaving the gun. By means of extensive experiments, conducted in the laboratories of the Johns Hopkins Hospital, on inanimate matter and animals, he was able to show that earlier notions of the subject were erroneous, and that both powder and projectile, when primarily infected by virulent organisms, like the bacilli of tetanus or anthrax, and shot into animals at all ranges up to five hundred yards, still carried these organisms, conveying the diseases to susceptible animals struck by them with the usual fatality. These experiments which are fully described in Colonel La Garde's Mütter Lecture on Poisoned Wounds by the Implements of Warfare, delivered before the College of Physicians at Philadelphia in December, 1902, soon prompted surgeons, military and other, to be more thorough in the treatment of gunshot wounds. Such a thing as a sterile gunshot wound is no longer advocated and the greatest care was thereafter taken to rid such wounds of septic matter introduced by the act of firing. These and other writings have given Colonel La Garde a wide reputation as a recognized authority on military surgery. In 1892, he was detailed as the medical member of a board of army officers to determine the best type of rifle and ammunition to be selected in changing the armament of the United States Army. His advice was of great value to the Government in selecting the kind of weapon which has since been in use by our foot and mounted troops.

Col. Jefferson R. Kean as Chief Surgeon of the Cuban Army of Pacification did yeoman service in the prevention of infectious diseases in that island, and is now director of the Red Cross and base hospital establishment.

The manuals of military medicine by Charles S. Tripler (1858), General Alfred A. Woodhull (1898), and Lieut. Colonel Paul F. Straub (1910), also the manual of military hygiene by Colonel Valery Havard (1909) are highly esteemed in the medical corps.

Lieut. Colonel Edward L. Munson, editor of the new *Military Surgeon* (1916), devised the Munson shoe for troops (1912) and has written valuable treatises on military hygiene (1901) and sanitary tactics (1911), the former having been a text-book in the British as well as the American army.

Dr. Joseph Y. Porter, Lt. Col., retired, has made a national reputation as State Health Officer of Florida which office he has conspicuously adorned for many years.

Among those who have made reputations outside the medical sciences are Dr. Elliot Coues, deceased, Major James C. Merrill, deceased, Captain Robert W. Shufeldt, retired, who have international renown as ornithologists, Lt. Col. Edgar A. Mearns, deceased, who accompanied Colonel Roosevelt to Africa, and was one of the leading ornithologists of the world; and Major Washington Matthews, deceased, who made important contributions to the science of anthropology, particularly to the folk-lore of the Navaho Indians. Major James Evelyn Pilcher (1857–1911), editor of the *Military Surgeon* (1907), wrote a valuable series of biographical memoirs of the Surgeons General of the Army (1905).

The administrative successors of Colonel Billings as Librarians of the Surgeon General's Office were Lt. Col. David L. Huntington, Major James C. Merrill, Major Walter Reed, whose achievements have already been referred to, Colonel Walter D. McCaw, who created the historical collections in the library, wrote the treatise on "Tropical Surgery" in Keen's Surgery, and is now Chief Surgeon on the Mexican Border, and the present incumbent. Among the recent medical archivists of the army medical establishment, Major Louis C. Duncan has made valuable medico-military studies of the battles of the Civil War (1912–14) and Lieut. Fielding H. Garrison (Medical Reserve Corps), editor of the *Index Medicus,* has contributed extensively to medical bibliography and medical history.

The Army Medical Corps has contributed to the line of the Army Major General Leonard Wood, late Chief of Staff, and to the staff Major General F. C. Ainsworth, late Adjutant General. The work of General Ainsworth in the reorganization of the Record and Pension Office, and of General Wood in Cuba and elsewhere are known to all.

Army surgeons of other nations include such great names as those of John Hunter, Sir Joseph Fayrer, Charles Murchison, Sir Ronald Ross, Sir David Bruce, Sir William B. Leishmann and Sir Leonard Rogers in England, the Langenbecks, the elder von Graefe, Dieffenbach, Stromeyer, Helmholtz, Cohnheim, Löffler and von Behring, in Germany, Laveran and Widal in France, and Pirogoff in Russia, and in variety of accomplishment, no doubt the Medical Corps of the United States Army is equalled, if not surpassed, by the work of the Indian Medical Service of Great Britain But, in preventive medicine, we believe that the scientific achievement of our Medical Corps is unequalled by that of any other army of modern times.

THE ECONOMIC SAVING OF HUMAN RESOURCES

By C. L. CLOSE

MANAGER BUREAU OF SAFETY, SANITATION AND WELFARE, UNITED STATES STEEL CORPORATION

THERE was a time not long ago when employers paid little attention to the welfare of employees. Plants were built and machinery installed with a view to economy of space and volume of production. Little thought was given to the conditions under which employees worked. The industrial pioneers in this country couldn't consider the wear and tear on human bodies. They were too busy developing processes and striving to become leaders of the world in manufacturing.

We stand first among the steel-making nations of the world to-day. The first furnace for smelting iron in the United States was built on the James River in 1621 by Englishmen under the guidance of John Berkeley. Their problem was that of the pioneer. The industry was new, the country undeveloped, the Indians hostile; guns were an important part of the equipment at the furnaces. But, not until fifty years ago, after the Civil War, were the activities started that have made this country the leading nation of the world in the manufacture of steel. It required men of courage for work of such magnitude. They perfected in fifty years an industry employing over half a million of people and producing annually more than ten hundred million dollars worth of the material most essential to our civilization. Over and over again these men risked all they had in the world, lost everything and afterward won back more than they had lost.

They had many problems to face, these pioneers, while they were performing the herculean task of developing this gigantic industry. Considering the difficulties under which they labored, should we not temper our criticism of them for failing to consider the finer details of the human side of steel making? Let us see what the large corporations are doing to solve the present day problems—particularly the United States Steel Corporation.

It is the task of the present generation to prevent accidents, to ward off disease and to promote social welfare. We shall make mistakes just as the preceding generation did, and it will fall to the next generation to correct our mistakes, as we have corrected some of the mistakes of our predecessors. The opportunity for study and experiment is much better to-day, and as we become enlightened our standards will be raised. Some things that are being done to-day, which may be considered in advance of the times, will, in a short time, be accepted as

nothing out of the ordinary. Not many years ago it was unusual for a plant to have toilet and washing facilities. To-day, no manufacturer would build a plant without including these things, as an essential part of the equipment. It is only because we are becoming more enlightened and are discovering things which those before us had neither the opportunity nor the time to discover.

Not until 1900 was it definitely proved that yellow fever can be transmitted only by the mosquito; and the elimination of this cause of yellow fever made possible the building of the Panama Canal. The inoculation against typhoid fever will work wonders in the saving of human lives, and this was unknown but a few years ago. Wonderful and important discoveries and changes have been made, such as, wireless telegraphy, telephone, electric light, heat and power. We have better opportunities for education; even our methods of education are changed. I can remember the day, and no doubt some of you can, when it meant punishment for a boy to be caught using a jack-knife on the school premises; to-day, many schools have manual training courses, and before long a school without such courses will be thought obsolete. These courses were not provided in the past because their value was not understood. Understanding has come only through study and investigation.

Many things are being done in the corporation which may be considered innovations, and it may be that we are making mistakes, but we are just now going through the experimental stages of some of this work, and it will fall to those who come later to correct them. While in recent years some thought was given to the human side of steel-making, and various attempts were made to improve conditions, there was no concerted or systematized effort until after the formation of the United States Steel Corporation.

Organization

In order to systematize and standardize the work that was being done by the subsidiary companies, the Steel Corporation, in 1906, appointed committees to study these matters. A safety committee was appointed, consisting of representatives of the larger subsidiary companies, who had already given some study to the subject of accident prevention. This committee now meets four times each year, conducts inspection by sending men from one company to another company's operations; studies serious accidents and recommends measures to prevent the recurrence of such accidents in any of the plants; passes upon safety devices and makes recommendations as to their use.

The good resulting from the work of this committee led to the appointment of other safety committees, including the central committee of safety for each subsidiary company, composed of representatives from the different plants of the company; its duties are similar to those

of the Steel Corporations Safety Committee, but with reference to its particular company only. There are also plant committees, composed of important officials of the plant; whose duties are similar to those of the Central Safety Committee, but with reference to their particular plant only. And there are department and special committees, made up of foremen, master mechanics and skilled workmen, who investigate particular problems, and workmen's safety committees from the rank and file of the mill, including even the foreigner who can not speak English. Their duties are to look for dangerous conditions and to recommend ways and means of preventing accidents. Members of these committees, especially of the plant committees, are changed frequently so that in due course each man in the plant shall serve upon the committee. Up to the present some 13,000 employees have served upon these committees and there are now 4,249 men so serving.

Accident Prevention

The results of the work on accident prevention have been very gratifying. Our serious and fatal accidents are about one half of what they were in 1906. We have saved since that time 14,967 men from serious or fatal injury. Approximately, five and one half million dollars have been spent in providing safeguards. Our efforts to-day are to educate our workmen in safer methods of work and to warn them against certain practises that are not only unnecessary, but often foolhardy. They had come to believe that "chance-taking" was a necessary part of their work.

First Aid and Rescue

Recognizing the fact that with the utmost care and the protection afforded by the most approved safety devices and apparatus, accidents will occasionally happen, the subsidiary companies have made provision for prompt attention to injured men and skilful care of them.

All the mining companies of the corporation have first aid and rescue crews composed of employees who are especially trained for the work. This service is purely voluntary on the part of the employees, but before any man is allowed to enter the work, he must have a doctor's certificate showing he is physically fit for the training and labor incidental to it. The system varies slightly in each company, but the general plan is as follows: Four to six men are assigned to each crew. They meet periodically and are trained by the company doctor. The course consists of lectures, demonstrations and drills. Twelve lessons are usually required to complete the course, and each man is given a certificate after he has qualified. The training of the men for the work goes on continually and many new crews are added each year. A number of crews are assigned to each mine.

At many of the manufacturing plants of the subsidiary companies

of the corporation men are trained in first aid work. The training is similar to that given in the mining companies. The primary object of first aid is to furnish an aseptic or clean dressing that will prevent infection in the wound.

As a necessary adjunct to first aid and rescue work in both mines and mills, emergency hospitals, completely equipped, have been provided. All cases of injury, no matter how trivial, are sent to the emergency hospitals or stations, where treatment is given by competent surgeons or trained nurses. Whenever the accident is of a serious nature, the injured man is taken to the emergency station, where first aid treatment is administered, and he is then transferred to the nearest hospital.

Relief

Also recognizing the fact that the burden of caring for the injured should be borne by the industry, the steel corporation established a voluntary accident relief plan, which was put into force before any such system had become law in the United States. This plan is purely voluntary and was put into operation by the corporation in May, 1910, and is for the benefit of all employees injured and the families of employees killed in the service of the subsidiary companies. The funds required to carry out the plan are provided by the companies, with no contribution whatever from the employees. Relief is paid regardless of legal liability and without legal proceedings; even application for relief is not required. This plan of relief is still in effect in those states where workmen's compensation laws have not been enacted. The amount paid in 1915 to and for our injured workmen, including expenditures both under our plan and Workmen's Compensation Laws was $1,694,465.29, or 85 per cent. of our total expenditures, on account of work accidents was paid out to the injured men and their families, or in taking care of them.

Sanitation

The work in sanitation has been organized in a manner almost identical with the safety organization, except that the sanitation committee is chosen from the presidents of the subsidiary companies with an officer of the United States Steel Corporation as one of its members. This committee administers the work through a subcommittee composed largely of technical representatives from each of the subsidiary companies.

In sanitation many improvements have been made in the proper investigation and observation of water supply and distribution to the employees. All sources of drinking water are analyzed periodically and great care is taken to prevent possible pollution by surface water or otherwise. The most modern sanitary methods are employed in the

cooling and distributing of the water, including the installation of sanitary drinking fountains—the common drinking cup has been practically eliminated.

The common or roller towel was abolished several years ago. The committee has prepared specifications covering general sanitary requirements and these are followed by the subsidiary companies when installations are made. An important requirement in these specifications is that no wash basins shall be installed. Facilities for washing the face and hands shall be such that employees must necessarily wash from the flowing stream. This may seem radical, but we think it important, in order to avoid any possible danger of spreading disease. Good toilet facilities have been installed at many plants and mines—these facilities usually including shower baths. A number of swimming pools have been built for the general use of the people in the mining towns.

In Alabama, where one of our mining companies conducts its operations, the conditions are favorable to mosquito breeding. The Tennessee Coal, Iron and Railroad Company especially, are doing much to prevent the spread of malaria fever. Streets and alleys are properly drained; pools and lowlands are drained or filled in, where practical; otherwise they are covered with crude petroleum. All known methods of fighting the mosquito are used. By these methods the number of cases of malaria fever has been greatly reduced, and the comfort of the people living in our camps has been increased. Over 200,000 circulars, explaining the dangers from the fly, were distributed among our employees last summer. This circular was written in simple language, easy to understand.

Metal garbage cans equipped with tight fitting covers are placed at the rear of each house in the mining camps, and at convenient places throughout the mills. Garbage and other waste materials are collected periodically and burned.

Some of the subjects of which the sanitation committee is now making a study are occupational diseases, mine sanitation, proper ventilation in plants and company houses; provisions for proper heating and lighting systems in plants; provisions for regulation of milk supply; dust removal at plants, including roadways.

Housing

In the ore mining regions of Minnesota, the ore and coal regions of Alabama, and the coal-mining sections of Pennsylvania and West Virginia, very satisfactory results have been attained in the housing of employees.

In the populous centers, such as Pittsburgh and Chicago, where

many corporation mills are located, the employees are merely a small portion of the city's population and are provided for in the ordinary way in which a city's people are housed, without the intervention of their employers. In such cases intervention by the employer would appear inadvisable, if not actually impossible. Where great plants have been built at some distance from any city, as in the cases of Gary and Duluth, the corporation has been obliged to provide houses for such large numbers of its employees that it has built industrial villages adjoining the plants.

It is believed the essential provisions of water supply, sewerage, lighting and other requirements for the public health of these towns can not be fairly criticized. The housing provided by the corporation in these towns is perhaps better suited to the needs of the skilled workmen than to the wages of the unskilled workmen. This is but natural, since the organization of the new plant demands first of all a force of skilled men, who must be drawn from older plants where they have established their families. In order to induce them to come to the new plant, provisions for housing them must be fully worked out beforehand, because they will not come and even temporarily shift for themselves, as the unskilled laborers, largely foreigners without families, are accustomed to do in the beginning. Furthermore, no industry in this country has, so far, solved satisfactorily the problem of housing unskilled foreign laborers, whose families have not yet followed them to this country. These men earn low wages, out of which they seek to save the utmost amount possible. They have been accustomed to ways of living which we must try to change, but which are much cheaper than those ways in which we wish to have them live.

In the hope of evolving some satisfactory method of housing these unskilled workmen, the corporation is now studying three types of houses.

First: Houses for occupation by families only, which can be rented for not more than $2.00 per room per month.

Second: Houses for occupation by families which follow the general custom of taking boarders, such houses to be especially adapted for that purpose, so that the family quarters may be apart from those of the boarders.

Third: Dormitories or barracks for men without families, where each man shall have a separate and sanitary room, however small and bare it may be, with common mess rooms, shower baths, etc.

We expect our new town, known as Morgan Park, Duluth, Minnesota, which is now being built to house the employees of the Minnesota Steel Company, to be one of the finest industrial towns in the country.

Gardens

In order to promote more healthful and pleasant living conditions, the subsidiary companies owning houses in which their employees live, have offered prizes each year for the best vegetable and flower gardens. Last year there were 6,963 of these gardens in the Frick Coke Company towns alone—95 per cent. of the total number that could have been planted. The estimated average value of each vegetable garden was $21.48, based upon the prices at which garden produce was sold by the stores in that vicinity. There were 6,633 vegetable gardens and this meant a saving to the employees of that company of $142,536.21. To further encourage thrift, the Tennessee Coal, Iron and Railroad Company in Alabama, where, because of the long season, a large proportion of its employees have mid-summer gardens, now offers prizes for the best gardens inspected in October. The climatic conditions in Alabama are more favorable to fall gardens than in any of the other localities in which our plants and mines are situated. Some of the companies have utilized the vacant land near their plants for community gardens. The ground is usually plowed at the expense of the company, and is then plotted and turned over to the employees for their use. Prizes are offered for the best gardens. Usually the amount of land allotted is insufficient to accommodate all those who desire to cultivate these plots.

Clubs

Many of the subsidiary companies have provided commodious and well-equipped clubhouses for the use of their employees, members of their families and friends. The features are:

Dormitories, reading room and library, gymnasium and swimming pool, baths (tub and shower), auditorium and dance hall, billiard and pool rooms, bowling alleys, basket-ball halls with motion pictures, lectures, concerts, smokers, musicals, etc.

The subsidiary companies pay all taxes and insurance and furnish heat. All other expenses are borne by the club members, the initiation fees and monthly dues being very small. In some cases these dues are fixed in proportion to the wages of the men.

Reading rooms are supplied with the current magazines and periodicals, daily papers and a good assortment of books. The social entertainments are a feature of the clubs. The affairs of the clubs are handled by the members themselves, in the usual way. Intoxicating liquors and gambling are prohibited.

Stock Subscription Plan

On December 31, 1915, more than 40,719 employees were stockholders under the stock subscription plan inaugurated in 1903. Their aggregate holdings are more than 178,898 shares of a par value of

$17,889,800. It is impossible to ascertain how many employees, in addition to those yet receiving the special benefits that continue for five years, hold stock upon which these special benefits have ceased to be paid, but it is believed that the number would greatly increase these figures.

Pensions

The United States Steel and Carnegie Pension Fund, which was established in 1910, by the joint action of the United States Steel Corporation and Mr. Andrew Carnegie, had a record of 9,002 pensioners on December 31, 1915. The amount paid in pensions during 1915 was $659,389.42.

Welfare

In welfare work of a character not already mentioned for the benefit of the workmen, the subsidiary companies are trying many interesting experiments, some of which have already proved very successful, and it is hoped that the others will be equally successful, so that the work may be further extended.

One of the most practical and successful of the new departments developed in connection with the welfare movement is that devoted to gardening and nature study. This department was inaugurated at the Duquesne Works of the Carnegie Steel Company during the summer of 1914, and the results were most encouraging. The principal gardens were conducted in connection with the Water Street Playgrounds. Here a number of old houses were removed, and the area vacated was apportioned into 144 small plots of 8 x 10 feet—and each plot allotted to a boy or girl. The children, aged 8 to 14 years, and representing ten different nationalities, were under the direction of a trained instructor and were given daily lessons in garden making. Each garden was planted with beans, beets, carrots, radishes and lettuce; and the actual labor of planting and caring for the gardens was performed by the children themselves. The little gardeners utilized the crops for home consumption, or sold them and used the money for their own purposes. In addition to the regular care of the gardens, the children study the germination of seeds. First, the development of the seedlings, showing the transformation of the dry seed into a living plant, which breathes, eats and grows just as human beings do. This gives an insight into the wonders of the living world, satisfies the natural curiosity of childhood and affords much pleasure.

Study of methods of planting is also insisted upon. The children are taught the necessity of a knowledge of the life and habits of the plant and are shown the results of right and wrong planting. Methods of cultivation are touched upon, and the result of each method is shown. Methods of fertilization follow in succession with demonstrations of the results of each method and practical advice as to the proper method to

be selected. Then comes the study of systems of irrigation and the conservation of soil water, showing the means employed and the effects produced. This is followed by study of the various functions of the plant.

Visiting Nurses

Visiting nurses are employed by the companies in a number of districts. Ordinarily they are under the direction of the local company physician or plant manager, although in some cases they are under the supervision of city visiting nurses' associations. Their duties are to visit the homes of employees, especially where there is sickness and the family would be benefited by the assistance or instructions of a trained nurse; to render such aid as will conduce to the comfort and welfare of the families; to instruct and direct mothers in the care and feeding of infants. These nurses explain the proper preparation of all food and advise in the matter of economical purchasing, discourage anything and everything tending to immorality, and teach the value and necessity of cleanliness and the benefits of fresh air and sunshine. Some of these nurses have been provided with a house which we call a "Practical Housekeeping Center"—a house of the ordinary type in the locality, furnished in a manner not beyond the means of the lower paid workmen, but in a better style than they had been accustomed to, before coming to this country. This house is used as the nurse's headquarters. Here she conducts classes and teaches the women and girls in the neighborhood the art of housekeeping in a practical and sanitary manner.

Playgrounds

One hundred and thirty-seven playgrounds for children have been provided by our subsidiary companies. In most cases they are on the company's unused land, and in some cases they are on city or private property, but the grounds are usually prepared and equipped at the expense of the company. Competent instructors employed by the company are in charge of the grounds. In addition to playground work, some companies provide instructions in sewing, basketry and handicraft. Motion pictures, both for instruction and amusement, are shown at night to parents as well as the children. Last summer there was a daily average attendance of 18,000 children at these playgrounds. Where these grounds are installed, it is immediately apparent that the standards of the children are raised. It is impossible to overestimate the influence for good exerted by these recreation features on the future lives of the boys and girls of the community in which they are located.

Educational Work

For many years the companies have been carrying on educational work among their employees, including vocational training and appren-

ticeship classes, and the teaching of English to foreigners. The purposes are:

To increase the efficiency of the workmen by teaching the fundamental and the more advanced principles involved in their individual lines of work.

To increase the earning power of the pupils by guiding them along the paths of quicker and deeper reasoning which lead to positions of gradually increasing responsibility in all departments of the mill.

To promote and develop the happiness of the pupils not only in their daily work in the shops and mills but in their home life as well by opening the door to a more thorough understanding of the meaning of life and work.

The courses are varied to meet the needs of every employee who is desirous of advancement, whether he is the graduate of a university or a man who has had no special school advantages. The teachers are men actively engaged in their respective lines, either in the mills or in the city. These men are selected because of their scholarship and broad practical experience in the branches they teach. The majority are assistants or foremen in the various departments of the mills, and, therefore, are personally acquainted with many of the students in their classes, which results in an increased mutual benefit. Actual mill problems are considered and studied in each step of the work as it is taken up in the prescribed courses, with the result that each pupil not only learns the principles involved in his own special line of work, but also those that must be understood before he is qualified for the position ahead.

Special and attractive inducements are offered to those who finish the courses.

The method of teaching English to the foreigners is usually that recommended and used successfully by the International Committee of the Y. M. C. A. in various industrial localities. The majority of the foreigners upon entering the school can not speak, read or write the English language. They are first taught simple English sentences and the names of objects with which they come in daily contact; then follows instruction in letter writing, and the filling out of money order blanks and naturalization papers. They are taught the elements of civil government; and the plan of the county, state and national governments, their departments, and the names of important officers and offices are carefully explained to them. The advanced pupils are taught writing, spelling, grammar, composition, civics and arithmetic; books on American history and geographical readers are used as text-books.

EDUCATION, EFFICIENCY AND ECONOMY, WITH SPECIAL REFERENCE TO MINING

By LANCASTER D. BURLING
CANADIAN GEOLOGICAL SURVEY

WE have all had an education, whether we got it within natural or artificial walls, as a measure of growth with our growth in the rough and ready school or in doses identical with the other members of a class in the school whose courses are served to some according to prescribed formulæ, to others as a table d'hôte meal, from which they can "elect" the things they want. Unless our education has received a "continental" finish, however, we have never had the opportunity of tasting the courses on the intellectual menu before we ordered.

Academic reform was a topic of the day during the years immediately preceding the fall of 1914. In the present days of stress it is a vital problem, for economy has now become a necessity, true economy is impossible without efficiency, and efficiency is a matter of education. Since any economy or efficiency which ignored our second ranking industry would be farcical, mining education has become and must continue to be an object of primary concern.

After previous wars, and with less of economic necessity, the world has forgotten; after this war necessity and the operation of that universal law which ever tends to minimize external friction will soon tear down reprisal barriers, unless, indeed, the better sense of nations fails to raise them, but a long period of adjustment must succeed the final restoration of international comity. That economic necessity will weigh upon the world with a vigor previously unsurpassed is indicated by the words of Mr. Asquith at the beginning of the year 1916:

> The nation's liabilities have already reached a figure which staggers the imagination and will strain its resources for a generation.

It is for our educational institutions to see to it that this scourge of economic necessity shall be beneficial, for we are convinced that intelligent direction will give it this effect.

If we are to hold our own in the period of industrial rivalry that is to come we must utilize our brain power. We must realize that pure research, though carried on without regard to gain, is the best investment a nation can assume, for its returns are certain and may be incalculably great. We must realize that science leads and its discoveries can not wait on industry. The phosphorus iron ores which mean so much to central Europe lay fallow until an English chemist solved the problem of converting them into steel. The constructive and the creative must replace the imitative—prevision must replace contemplation—qualities of youth, and we are young. But we shall need the leadership of men who believe in the principle laid down by Disraeli:

Economy does not consist in the reckless reduction of estimates; on the contrary, such a course almost necessarily tends to increased expenditures. There can be no economy where there is no efficiency.

The penalty a democracy has to pay for being a democracy is the fact that the good of the majority must wait upon its will. But the progress of the race demands a minority intelligence that shall "scorn the decisions of an unjust majority," a minority intelligence in whom the better ideas shall originate and in whom there is a willingness to carry to the extent of personal sacrifice the education of the electorate.

Several million voters will have been doing for months what they were told to do. Why? Because the men who told them knew. Well, when our men of science tell us what we ought to do, let's do it. It is hard to believe that men who have taken life at the command of an officer will not vote for the conservation of life at the request of a scientist; that men who have mined trenches for the purpose of producing casualties in the enemy will need encouragement to prevent casualties in their own ranks in the mines of peace; that men who have been part and parcel of an organization which depends on the scrutiny of detail, thorough preparation and purposeful procedure will tolerate the absence of this scientific attitude in the days of peace; and that men who are physically unfit through the accidents of war will not realize the necessity of developing and conserving the physical fitness of a people. It is for us, individuals or nations, who are not participating in the baptism through which they are passing to see to it that we shall not be the ones to clog the wheels of progress. Let us realize that we shall never act for the good of all until we master the problem of acting for our own good, and that we are masters of more than our own destiny. Nations are a people in partnership and we are each responsible for our share.

The involuntary chemicalization that is going on in the body politic of the world presages a crystallization that will not be content with other things as they have been. The best brains of our educational men should be organized now for a voluntary chemicalization of our own, that we may crystallize a scheme that shall bear the acid test of the coming years, for test there will be, and the best results for education will come if this chemicalization goes on under the proper control rather than under the stress of immediate necessity. Sudden readjustments are dramatic, but quiet preparation now for what is going to happen next year, five years from now, or a generation hence, is the thing that counts. In the words of President Eliot:

Nature's patient ways shame hasty little man.

Whether or not the life work of many of our graduates is to follow closely the lines for which they may have trained the engineering which they receive should be a practical habit of thought rather than a specific fund of knowledge. The opposite viewpoint receives abundant confirma-

tion, however, in the establishment, among the universities of North America, of 85 separate and distinct degrees in engineering, 63 undergraduate and 22 postgraduate. The same tendency is to be observed in the number of courses offered to the students of our schools, but it has seldom reached the degree of absurdity obtaining in the University of Pittsburgh. Fiction pales before the truth of the following paragraph from the eighth annual report of the Carnegie Foundation:

> The catalogue of the University of Pittsburgh gives the names of a dean, a professor, and three instructors who offer one hundred and fifty-six courses in geology; three of the five offer also ninety-two courses in crystallography, mineralogy and lithology, and sixty-three courses in petrography; two of these three offer also two hundred and forty-three courses in mining geology; one of these two also bears one half the burden of one hundred and sixty-two courses in ceramics; of the remaining two of the five, one bears also one half the burden of one hundred and five courses in paleontology and one also offers sixty-three in paleobotany. Together these five men announce, probably in addition to other work in other parts of the university, a grand total of seven hundred and fifty courses, one of the five, an instructor, being alone responsible for two hundred and eighty-five. Even though all of these courses were announced for a single term only, these men would each have to give from forty to seventy courses at one time, which is preposterous.

Such a condition would convert almost any one to the opinion expressed by Professor J. C. Brown, of Liverpool:

> It would be far better to teach one science subject substantially and well than to teach a smattering of several.

If a defendant of our present system of technical education were to ask me then to explain the efficiency of our engineering courses, I should say that it is to be ascribed almost solely to the fact that for four years the mental powers of the student are taxed to the limit.

You hear it said: "Mining schools are here to teach mining, not to develop culture." However defensible the stand that our universities should develop culture, their present danger is one of even neutralizing the cultural effect of a student's previous training by a system of too close application to the purely technical. But it is not so much what we study as how it is taught.

Our mining schools are not aiming at the production of well-educated or particularly skilful miners, but engineers—a difference that is expressed in terms both of mental processes and methods of attack—and the number of men in training should have little to do with the number of vacant jobs. As long as mining is carried on, so long will there be a demand for trained men, and the demand will be proportional to the supply just as far as that supply is efficient. To paraphrase a sentence from Perkins' "Some Things to Think About": What we need to-day is mines managed by engineers, not by opticians or milliners who happened to get side-tracked while they were in college.

True education bridges the gap betwen the mechanic and the engineer, the imitative and the creative—it is a process which is successful

to the degree in which it prepares a man for the responsibilities of a citizen and can not be measured solely by his success as a mine manager. How then are we to explain the failure of the mining engineer either to assume or to be accorded his proper place in the commonwealth of civil effort? Placing the blame for such a condition upon our own indifference is unsatisfactory, because it ignores the source of that attitude and gives us no assurance that the next generation shall not be as indifferent. Graduation from our mining schools should not be possible to any man who does not appreciate the economic value of a miner, who is not a conservationist to the backbone, who does not appreciate the fact that unlike forestry and some of the other things we hear so much about, human industry has had nothing to do with the production of the heritage which he is to exploit; that it is both expendable and irreplaceable. He must be endowed not only with "superior professional efficiency," but with those qualities which will enable him to cope successfully with the larger problems of our time. We hear a great deal about making our college courses such that our graduates will be adjustable; well, being adjustable bears about the same relation to human progress that watching a baseball game does to physical development. We need men who can and will do some adjusting themselves. Mann believed that one former was worth a thousand reformers; what would have been his ratio between formers and conformers?

Where do we stand and what can we do? And let us not be concerned so much with the level of our attainment as the direction of our going.

When we are told that the miners of the United States mine five times as much coal per day as do those of Belgium, we want to know why. Is it due to efficiency or is it due to the fact that the United States miner is allowed to waste a ton and a half of coal for every three which he sends to the surface? A ton and a half for every working day of every man in an army of three quarters of a million men. Or does the Belgian waste as much?

Why can a Nova Scotian mine over three times as much coal in a day as a Belgian? Has the difference in speed any bearing on the fact that the average number killed per year per thousand employed is nearly two and one half times as great in Nova Scotia as in Belgium, or are these figures hopelessly complicated by the fact that the number killed per million tons produced is nearly the same in both countries and that the Belgian miner works forty more days in the year and is therefore exposed to danger for that much longer period of time?

Why can the Belgian miner average forty more days in the year than the Nova Scotian, or eighty more than the American? Is it because the Belgian mines are better organized, because they are not shut down by accident so frequently, because of a better adjustment between supply and demand, or what?

Why should the ratio of coal miners killed per thousand employed remain practically stationary in the United States, Belgium, France, Germany and Japan, even on the decrease in New South Wales, while the ratio in Great Britain, India, British Columbia and Nova Scotia is increasing?

When a Montana mining company can effect an annual saving of two million dollars, or the equivalent of fifty cents per ton of ore mined, by the substitution of hydroelectric power for steam (and there is plenty of coal in Montana) is there not something here to ponder over and translate into action?

When the disparity between the deaths by accident to coal miners and to those in other occupations is traceable to defects in our mine workings should we longer depend on voluntary effort?

When an efficiency expert can take a man who has been loading pig iron on to cars at the rate of twelve tons per day and make him load forty-seven tons the next day with less fatigue, should not common sense so swell the ranks of the progressive as to eliminate the economic waste of inefficiency?

Education, not instruction, is the first step in the removal of difficulties like these, but the principle of the greatest good to the greatest number and an economic necessity that will not be denied may demand that where growth is too slow, voluntary effort too half-hearted and too provincial, legal process shall enforce conscription. A coal miner can stoop, so we wait to gouge out the floors of our levels until the roof hits the back of a mule. It is time that tendency gave place to forethought and design in the conduct of our mining operations.

As a constructive program and in addition to those changes in the spirit and ideals of our educational institutions which have been suggested, I venture to enumerate the following, not with the idea that it is complete or has not already been adopted, at least in part, but that it provides a mechanism capable of immediate application and elastic enough to provide for the expansion of the future:

First, the establishment of governmental advisory scientific commissions;

Second, the establishment of governmental "foundations for the advancement of teaching";

Third, the appointment of governmental efficiency experts, consulting master-workers in the business field.

With regard to the *advisory scientific commissions:* The British Advisory Council for Scientific and Industrial Research, the National Research Council of the United States, the Commonwealth Advisory Council on Science and Industry of Australia, and the Advisory Research Council of Canada[1] represent the tendency of the times. The

[1] The expansion of this list to include the research councils of the United States, Australia and Canada will indicate the extent to which the active collabo-

members should have such scientific standing as to inspire confidence and be so free from political, sectional, social, religious and financial bias that the disinterestedness of their public service shall be unquestioned from the start. Such a commission should be ready to consider any and every serious scientific problem referred to it, but the passive function of a disburser of information at the request of others should be the least of its activities. It should watch proposed legislation and should not only inform those interested whether history has proved or scrapped the chosen method of solving the problem, but suggest that method of procedure which the accumulated experience of the world has proved best. Finally, and most important of all, it should initiate reform and suggest legislation. It should be authorized to call in the aid upon special problems, of acknowledged experts, whether they be members of the commission or not.

It should be all-embracive in its scope and national in its institution and effect, a "general staff," if you will, which shall apply to industrial armies the combined wisdom of their experts. It should include the executive heads, or their delegated representatives, of the various scientific bureaus of the government and should be the means of introducing a much-needed cooperation, not only among these organizations, but between them and the scientific world at large. In the procession of the Juggernaut the organized effort of a comparatively small body of men is often necessary to the completion of a task for which the devoted, even frenzied, effort of the multitude has proven incapable. It is evident that the very get-at-ableness of such an organization as has been outlined will insure its frequent utilization, and there can be no doubt as to the value of such a referendum upon proposed legislation.

With regard to the *foundations for the advancement of teaching*. Let us read the concluding statement of the Parliamentary Commission of Great Britain on British charities, an investigation covering more than twenty thousand charities, carried on over a period of nineteen years, and published in forty volumes:

> Of all objects of charity, the highest education has proved wisest, best and most efficient . . . because in improving higher education all other good causes are most effectually aided.

Then let us ask ourselves whether governments should not undertake work comparable in many respects with that done by private initiative in the Carnegie Foundation for the Advancement of Teaching in North America. Economic necessity may decrease the number of students in our universities, it will decrease the number who can afford to continue their work past the allotted term. This postgraduate training is essential to the development of the minority intelligence of which

ration of our scientific men has become something more than the tendency it was when the British Council led the way, but no further changes have been made in the text.

we have already spoken and the first expression of the desire of such a foundation to improve the cause of higher education might well take the shape of the establishment of endowed fellowships at those educational institutions competent to equip and direct research. These institutions should be the best in each country and should be selected without fear or favor. The number of fellowships assigned to each should be determined solely on the basis of facilities and the selection of candidates should be so safeguarded as to secure only men of large caliber.

A second mode of expression on the part of the foundation would be the establishment of a considerable number of what might be called traveling fellowships, open to men already in the government employ and to qualified holders of the state-endowed fellowships, for the purpose of resident work in the educational institutions of other countries that shall immediately acquaint their governments with the best thought and the latest developments in the world of science and the arts—an open service of peace instead of the secret service of war—what the Japanese have been doing for years with such telling effect.

The Carnegie Foundation is now providing pensions for the aged and incapacitated professors in the educational institutions of the first rank in Canada and the United States, and such assistance need not therefore be an immediate concern of the governmental foundations in these countries.

In extending its fellowship only to those institutions maintaining certain standards the Carnegie Foundation has been the means of measurably raising the standard of many of the universities of the United States and Canada. In another way, and perhaps it is the farther reaching, it achieves a real effectiveness through the fearless thrusting of offending schools into the pillory of print. Governmental foundations, whatever their authority, might likewise well replace dictation to the spider with education of the fly.

A third, and not the least important, field is that of educational extension, of carrying to the people the information we have kept for those enrolled in institutions.

If the Royal Commission which has been investigating the increase in the cost of living is correct in asserting that one of the main reasons for the evil which it has been investigating is the lack of efficiency in educational systems there is already an abundant field for such foundations as we have outlined. Furthermore, we shall be in possession, during the days that are to come, of the machinery necessary for the handling of any critical situation that may develop in the field of education. We believe that the activities suggested are justified by the present emergency and that their successful operation will produce tangible results. In any case, however, the method of execution must insure cooperation between the foundations and existing educational departments—not so much because this is in the best interests of the scheme

outlined as because such cooperation is essential to the development of higher education.

With regard to the *efficiency expert:* Let us look for a moment at the possible results. A private concern once paid an efficiency expert $150,000 to introduce efficiency in its plant; in the third year under the new régime the resultant saving per year had reached $1,500,000. A foundry in the western part of the United States regularly uses three men to charge a cupola and has continued to do this for twenty years in spite of the fact that in another foundry two men regularly charge a cupola of twice the size, a general inefficiency in the first foundry which enables the second to turn out its finished castings for less than half as much per hundred pounds. The economic pressure of a Panama Canal toll was met by the substitution of oil for coal in the engines of the "Kroonland." The increased expenditure per trip was to be $10,000, the resultant saving per trip, in wages and increased freight carrying capacity, was $35,000. Why did they wait for necessity to compel them to make $25,000 per trip? And why do others now?

The magnitude of the extra charges we may be called upon to meet are incalculable at the present time, and it may be better for the world if these are large enough to dwarf accepted methods of economics, and enforce the fundamental principle of efficiency, of doing things the right way. Indeed, the means at our disposal are so vast that the world may experience a financial recovery that shall be more wonderful than that of France in the early seventies because it will be comparably rapid and more widely beneficial.

We gauge the value of the thing received by the price we pay, and if there were no penalties attached to geographical position, and if there were uniform waste or saving in production, transport, sale and use, this would be true. However, the expert worth having will demand a salary high enough to satisfy us all as to the merit of his recommendations. Our awakening will come in the familiar ring of such suggestions as a fiscal policy that will give to each no more, no less, than he produces, the sharing by the idle of the supertax which we place on the busy, and the efficient use of land at hand and already under cultivation, rather than the hard-earned conquest of remoter areas, in the obviousness of the easy ways which he points out, and in the magnitude of the sums involved. We could do it but we don't; we are going to have to and we need a leader.

Let us remember that that something which will prevent accidents and conserve life, that will prevent waste and conserve resources, that will usher in the spirit rather than the letter of reform, that will make our graduates citizens as well as members of their craft, that will place pure science in the van of industry, that will harness up our brain power, that will replace opportunism with intelligent design in our industrial operations, and that will give us that efficiency which alone spells true economy, is education.

SCIENCE AND MODERN CIVILIZATION[1]

BY MAYNARD M. METCALF

THE ORCHARD LABORATORY, OBERLIN, OHIO

IN the human body there are many important organs each of which is controlled by nerves or internal stimuli acting in opposition to one another. The heart for example has its accelerator nerve fibers which quicken its beat and another set of inhibitor fibers which retard its activity. The balance and interaction of these controlling stimuli regulate the heart action according to the needs of the body. The same principle of control by opposed stimuli prevails in practically all activities of the body. In the arm the extensor and the flexor muscles are opposed and their interaction is necessary to properly directed movement of the arm. The same is true of the leg. The muscles that bend the body toward the right side are opposed by those which would bend it to the left. All the skeletal muscles are thus counterbalanced. In nervous control of the involuntary muscles there is a double set of nervous stimuli acting in opposition to one another. The same is true of nervous direction of secretion in glands. The internal secretions, hormones, are similarly balanced against one another. Tension, stability, accurately directed movement or chemical activity comes in physiological processes through the interaction of opposed directive stimuli. In psychic activities the same principle obtains. One finds direction secured by balancing pain against pleasure and duty against desire.

Phenomena in the inorganic realm show the same principle of control through opposed forces. The stars in their courses are thus held true to their orbits, and, at the other extreme, in the realm of the minute, molecular motion shows control through opposing forces of attraction and repulsion. The principle of direction or control of action through opposing forces or stimuli is widespread in nature.

Human society is similarly affected by opposed tendencies which like the two reins of a horse's harness guide the organism along its path. Socialism and individualism are one such pair of contrasted ideals, both sound, both esential to the guidance of society in its progress.

Our subject suggests a slightly different pair of similarly opposed ideals which may equally truly be regarded as guiding reins of society. I mean what we may call conservatism and radicalism, or traditionalism and experimentism, the binding conserving forces of society on the one

[1] Part of an address delivered before the Chinese Students Alliance at their conference in Oberlin, September 8, 1916.

hand, and the progressive ferments on the other. Perhaps as good phrases as we can find under which to summarize these two groups of influences would be traditionalism[2] and the scientific spirit.

Many men of science are accustomed to decry the spirit of conservatism but all our study of the processes of nature shows us inertia and force in opposition and the inertia is as vitally important as the force.

In human society it is well to have the conservative and the radical forces at work at the same time, but history shows us that the proper balance between them has not always been maintained. During the dark ages of the western world inertia, conservatism, traditionalism, was too dominant and stagnation was the result. During the French Revolution, on the other hand, radicalism ruled without the needed restraints and social results followed which might fairly be called explosive, so ill directed were they. It is possible for two oarsmen to propel a boat by each using his oar without reference to the other, but the progress of the boat, while real, will be very erratic in its course and the goal reached will be very uncertain. Steady progress in a desirable direction comes through properly balanced effort by the two oarsmen at the same time, each in a sense working against the other, yet the two cooperating through their opposition in the progress of the boat.

Two special features of value may be noted in the conservatism of society. To mention the lesser first, the human quality of subservience to custom makes it difficult for a new idea to make its way. It meets opposition and has to prove, often by strenuous effort, its right to prevail, and in this struggle the new conception is itself brought into truer proportions and is perfected.

But far more fundamental is the chief value of conservatism, of social custom. It is the essential foundation for stability, without which there can be no equilibrium and no equable progress. We must be able to know what to count upon in human action, otherwise we can not properly relate our own activities to those of our fellows and to that of society as a whole. If it were a matter of varying chance whether the sun should rise from day to day, if we could not tell confidently in advance whether fire would burn or not, if there were no stable predictable custom in the behavior of things animate and inanimate, chaos would result. And this is just as true of social conditions as it is of all others. Custom is the foundation of all social life and without it there could be no human society.

Custom prevails to differing degrees in the behavior of different

[2] I am making no attempt in this discussion to discriminate between reasonable and unreasonable conservatism, for even unreasonable conservatism serves its useful purpose in society however much hindrance it may also cause. Of course the phrase "scientific spirit" should include a large measure of reasonable conservatism.

organisms. Among the higher plants reaction is almost as predictable as in the inorganic realm. Among the lower forms of animals reaction seems to be determined by the racial or specific character of the organism rather than by its plastic response to conditions newly presented. It does what it is bred in it to do. The response, to use a common though not strictly scientific phraseology, is instinctive rather than intelligent, or we may say it is racial rather than individual. It is only among the highest animals, perhaps only in the case of man himself, that intelligent response involving judgment comes into play.

Similarly in the development of man and of society, custom was at first probably almost wholly dominant, individual independence of the group ideals being a late development. It is still true of most men that they act in accordance with social custom and not upon their own independently formed judgments. Comparatively rarely, indeed, does any person think or act in even a single instance in independence of social convention. In great preponderance, human activity is racial or communal and not individual.

But even as the presence of individuality is a sign among animals of a high place in the realm of being, so among men independence of social convention and the ability to think for one's self, the habit of self-dependent rather than socially subservient action, marks a highly developed man.

We have here a paradox. Society in its evolution comes to produce, more and more, men who are to a degree independent of society, and the percentage of such spiritually independent men in any society is perhaps a fair criterion of the degree of advancement of that society. Among the bees, the hive is everything, each individual being wholly subordinated to the group, and the presence in the hive of uncoordinated members would be disastrous. In human society, on the other hand, the presence of individuals of independent spirit is essential to the vitality of the group. Yet here, as among the bees, overemphasized individualism means the destruction of society. Two qualities, traditionalism and personal independence, two opposing ideals, socialism and individualism, working each against the other are necessary to vitality.

Some years ago, Mr. Harris, then United States commissioner of education, said (I quote from memory) that "the primary function of public education is to persuade the individual to conform to the conventions of society." Contrast this by no means false statement with another by a scholar of old, Paul of Tarsus, who said: "Test all things and hold fast that which proves to be good." The first is the word of the traditionalist and emphasizes the essential quality of social stability. The second is the utterance of the greatest heretic of Christian history and is a fair statement of the spirit of true science: prove all things and hold fast that which is good.

In China traditionalism has ruled for several centuries, and progress has been but slight. Her great need to-day is a liberal infusion of the scientific spirit, to restore the proper balance and secure progress.

But many regard the scientific spirit as dangerous. It is dangerous. It is powerful, it overthrows, it destroys, it starts things moving. But all power is a dangerous weapon, dangerous to the good when wielded by the evilly disposed or the ignorant, dangerous to intrenched evil and incompetence when wielded by the man of high ideal. Huxley was a very striking embodiment of the scientific spirit in the last generation. He was a destructive force, militant against all shams. But he was one of the greatest prophets of God in all his generation, battling manfully, inspiringly, against insincerity and dishonesty wherever found. In the Christian church he found too much respect for dogma and too little regard for truth, and he fought this evil in the church while the church fought him, but among all his Christian opponents was not one who so nobly served the church as did Huxley. The church needed castigation, needed to be held up to itself so clearly that it could see its own subservience to traditionalism, needed to recognize itself a worshiper of the "established" rather than of the true.

Huxley was a very militant example of the man of scientific spirit. One need not always be a fighter. He may be of the milder type and, while devoted to seeking and doing the truth, may let the truth do her own fighting, and she will.

In the orient conservatism has long been too dominant.[3] Society has crystallized, has lost its plasticity and is not flowing forward on its course. There are recent indications that the depths are stirring, and if an explosion is to be avoided there must be a widespread infusion of the solving influence of the scientific spirit of progress.

How can this scientific spirit be introduced? Talking about it accomplishes little. We can not merely say "go to, now, let us all be scientific." The roots of conventionalism have struck too deep into society for any easy change. The fresher spirit can come only by growth, probably at first disappointingly slow. But this growth can be helped to start and to reach a full and rich development.

It can not be helped much by precept, nor will the example of other nations be sufficient. The scientific spirit grows by exercise. The doing of the daily tasks of science brings the spirit of science. The introduction of scientific research is the means.

How can this be brought about? How may research be introduced into a nation's life and be fostered? Modern industry is increasingly dependent upon chemistry and physics and the introduction of manufacture will bring them in its train. Engineering is science of the high-

[3] Japan should not be included in this statement.

est order. The introduction of industrialism and its attendant engineering will make very plain the need for scientific training.

Perhaps the most important event, the most hopeful feature in recent Chinese history is the establishment in China of institutions of modern medicine of the strongest, most scientific, type, through the great Rockefeller trust and the cooperation of missionary schools. Medicine touches human lives most intimately and brings relief to our loved ones as well as ourselves. Its appeal is peculiarly strong and vivid. The results of communal hygiene and of scientific resistance to epidemics, as well as the cure of individual maladies, make a striking appeal. Vivid realization of the contrast between modern science and tradition could perhaps nowhere else be so well presented as in medicine. It is a better introduction for the scientific spirit than is even industrialism.

But for China to gain the needed benefit from the introduction of scientific methods in medicine, industry and engineering, for her to get inspiration, to attain through them to the scientific spirit, she must engage in these activities herself. It is not enough to bring in western physicians, to import engineers and factory managers. These will be necessary, but they are not enough. Japan was very wise in one most important particular in introducing western science. She manned her universities and factories at first with western men, but she sent her sons to them to learn, and they did learn. To-day Japan is productive in all fields of scientific research, and her life is becoming as much guided by the scientific spirit as is that of the more progressive of the western nations. It is not enough that western nations should come into China, should develop her mining, her forestry, her agriculture for her, build her railroads and bridges, cure her sick, organize and direct her public health work. China must learn to do these things for herself, and through the doing, reach the real scientific spirit, the spirit of independent judgment of things upon their merits, of proving all things and holding fast that which is good. To this end industrial education, engineering colleges, schools of modern medicine, are needed. Scientific laboratories in colleges and schools and in connection with industrial establishments will teach the ways of science and develop the independent spirit of regard for truth, however contrary to tradition it may prove to be.

This may seem to some a prosaic program, but it will prove far from prosaic. The greatest adventure for a man or a nation is the search for truth and the gaining by faithful service of an unswerving loyalty to truth.

Thus far we have discussed changes that may be expected in the near future, within the next century or half century, changes that are already beginning and which are sure to gather increasing momentum.

It may not be without interest to take a look into the more distant future. What is to be China's ultimate contribution to the world? When she realizes her full development, what will be her share in the world's life?

The biologist has the principles of evolution as the background of all his thinking. He thinks of ethnic and racial problems in terms of centuries and decades of centuries whereas the sociologist thinks more in decades of years. What of the distant future as the evolutionist sees it?

True humankind came into existence apparently about half a million years ago. Of primitive man in Asia we know little, for the paleontology of Asia has been but little studied. Of man in Europe we know more. The earliest human remains in Europe are of a type of man—*Homo neanderthalensis*—now wholly extinct. He was succeeded by *Homo sapiens,* a species which in the course of many thousands of years has given rise to many offshoots which have become more or less distinctly marked subspecies or races. It seems that all races of men now existent belong to this one great species—*Homo sapiens.*

The great diversity of human races has been developed largely through isolation. Mankind spread from their center of origin out over Asia, Africa, Europe and America and the islands of the Pacific, each group coming to occupy a more or less distinct portion of the earth and each group, lacking contact with the other groups, developed independently, evolving into a race more or less divergent from the others. All of man's divergent evolution by which the several races have arisen, took place under conditions of isolation. If the ancestors of Swede and Arab, Saxon and Negro, Greek and Chinaman had all lived together and freely intermarried there would never have been any Swedes, Arabs, Saxons, Greeks or Chinamen, but instead a homogeneous race differing from them all. It is isolation which has allowed the several races of man to develop, to evolve.

But to-day isolation is rapidly being removed. Our means of transportation and of interchange of thought have been so developed, and the world's population is so increasing and spreading into all suitable quarters of the globe, that all men are rapidly becoming neighbors. We are just at the dawn of the day when all men shall live together. And this means not only interchange of cultures, but personal mingling as well. Hereafter no race can develop independently of the rest of mankind. Divergent evolution into races more and more distinct has ceased. We are entering upon a new anthropological period, a period in which divergent evolution has ended and a fusion of the races will begin. Increasing fusion will remove the present rather clearly demarcated racial diversities and the ultimate human species will be one complex race, fused from all those present races which succeed in per-

sisting. With the intermingling of the peoples in their social life, which is increasingly coming the world over, amalgamation could not be prevented, however strongly we might desire to prevent it. The illegitimate unions that would occur, however strong might be prejudice against interracial marriage, would be enough to obliterate in time all race distinction.

In this country there has long been and there is to-day a strong prejudice against intermarriage between the negro and the white man, and those states in which the negroes chiefly live have adopted stringent laws against such intermarriage. Yet in spite of this vigorous prejudice and strict legal enactment the negro in America is rapidly becoming whitened. A few more centuries and any demarcation between negro and white man in this country can not be drawn.

The Jew has been hated in Europe for a thousand years and more. His pride has met his persecutors, and his pride and their hatred have made the strongest bar to intermarriage which one can imagine. We in America can hardly realize the bitterness of the hatred and the social ostracism of the Jew, which has obtained for centuries in Europe and western Asia. Yet in spite of this bar to racial fusion, the strongest humankind could erect, the fusion has gone steadily on. The Syrian Jew is largely a Syrian, the Spanish Jew has many Spanish characteristics. The German Jew has Teuton qualities, and the Russian Jew is largely a Slav. In each country the Jew resembles his Christian or Mohammedan neighbor as much as or more than he resembles his brother Jew in some distant country. Racial prejudice, social ostracism, legal enactment, are all powerless to stop the resistless trend toward racial fusion when diverse races are in actual contact. Amalgamation of all human races which shall survive is inevitable. Whether the thought is agreeable or disagreeable makes no difference in the result. There can be ultimately but one human race and we must fit our thinking to this fact.

From this point of view the questions of chief interest in regard to any race are, first, will it persist and form a part of the ultimate race; and, second, what will be the nature and effect of its contribution to the ultimate race?

Some races apparently will not persist but will succumb and become extinct, as a result of the closer contacts and severer rivalry of advancing civilization. The North American Indian, perhaps the noblest of all savage races, rivalled only by the Maori and the Zulu, seems destined to extinction. So also is the Pueblo Indian of the central regions of this hemisphere. Both these races are stiff and unyielding, too lacking in plasticity to make the necessary readjustments in their character to allow them to fit with their new neighbors into the complex life of the mixed race which is to people America. Indeed both of these

highly developed American native peoples are already approaching extinction.

The aborigines of Australia are going the same road to destruction and the Tasmanians are already extinct. Without ill treatment, but merely through their own lack of adaptability, it seems that some, perhaps many, of the less numerous races must succumb under the new conditions so rapidly approaching. But not all the more primitive races are headed toward extinction. The negro has shown himself very adaptable. He fits into such place as is given him and readily learns the ways of complex society, showing a remarkably high capacity for social education.

It is no easy thing to say which races will persist and which will drop out. We can not safely say the races at present well advanced will continue and that the backward are doomed. The problem is one that has received very little study and it will long form a most enticing puzzle.

If there is any race that seems sure to persist and form a great part of the ultimate race, it is the Chinese. Their great numbers, their remarkable ability to live upon a low economic plane and to thrive, their love of peace, their great stability of personal character, their fine intellectual abilities and their capacity for response to the highest moral conceptions all indicate that the race will persist and will form numerically at least a most important element in the ultimate race.

But what of their influence in guiding and determining the type of civilization under which this ultimate race shall live? Will the Chinese contribute as much intellectually and morally as they will in numbers? This probably depends largely upon their success in wisely guiding their own growth under the new conditions that are approaching.

China has already made a major contribution to human progress. The ancient civilization of China spread to Korea and then to Japan and has profoundly influenced a great portion of mankind. Can she "come back," as the athletes say, and make another great contribution to the social development of the world? No nation has ever yet succeeded in making a second major contribution to the world's progress. Egypt, Assyria, Phoenicia, Greece, Rome, Arabia, Persia have each reached a high degree of culture and have then gone down. The Italian Renaissance, the only apparent exception, was not a revival of old Rome. Much foreign blood had been infused into the old Italian stock till they were an essentially new people.

Thirty years ago Edward Carpenter in a keenly interesting essay—"Civilization, its Cause and Cure"—showed the course of what he called the disease of civilization among those peoples which had reached a high degree of social development and had become dominant each in its turn. This disease has had much the same prodromal stages in all

cases, has culminated in a feverish development and has left the race permanently weakened. No people thus far in the world's history has ever made a good recovery or grown again into world power.

Will China prove an exception? She has once profoundly influenced the world's progress and at that time she reached a degree of culture which in art at least and possibly in some other features is still unsurpassed. Since this, her perihelion, China has gone down, and in later centuries the world has moved on scarcely conscious of China's existence. She has been a fallow field, lying quiet and producing little if any growth. Will she prove like the farmer's fallow field? Has her potential fertility been increasing during these centuries of inactivity? Is she now ready to receive new seed and produce again rich fruit? Who can say? It really seems as if she might be the first of all peoples to show this miracle of regeneration.

Is the disease civilization necessarily and inevitably so disastrous as it has thus far proved for all peoples? May it be that there is an untried cure, an antitoxin that will neutralize its poison? I believe there is such an antidote if we prove able to apply it.

Our knowledge of the principles of breeding, of genetics, is becoming such that we could, if we would, breed a progressively perfecting race. But you know the reply of the small boy who was asked if he couldn't behave for just an hour. He said: "Oh, I could if I would. But I couldn't would." We can breed a stronger and stronger human race if we will, but can we will?

Let us look a moment at this science of genetics and see a little of its phenomena and methods. It is only within the last half generation that we have come to know what it is that is inherited. A man does not inherit a general resemblance to either of his parents or a general blend of the two. He inherits, rather, definite particular qualities and his character is a complex mosaic made up of these many units. Or to be more accurate we should say he receives from his parents, many minute particles of protoplasm each of which is a determiner for a particular unit quality. In general there are two determiners, for each unit quality, one from one parent and the other from the second parent, and the nature of any particular unit quality in the offspring depends upon the interaction of its two determiners, the one received from the male parent, the other from the female parent.

This is not an appropriate occasion for discussing in any detail the phenomena of inheritance. For our present purpose it is sufficient to say that we have learned how so to manipulate organisms in breeding that we can select and combine their unit qualities in almost any manner we choose, thus controlling, predetermining, the nature of the organisms. For example, some years ago there were known two esteemed varieties of the tobacco plant, one with very large leaves and the other

with very numerous leaves. It was determined to combine these two and thus get a variety with both very numerous and very large leaves, and this was easily done. We can control and predetermine the character of animals in the same way. This would be as true of man as of any other animal, if we were free to control human marriage as readily as we determine matings in animal breeding. But, of course, this is not possible, and without such definite and exact control over marriage the process of eugenic improvement in humankind must be very slow.

The subject is one requiring extended and very careful treatment and can not really be included in our thought this morning, though it is the most important thing of all in considering the outlook for the ultimate human race. Let me leave with you just this one suggestion. We can so educate ourselves to higher and higher ideals that not physical beauty nor prowess alone, not intellectual ability nor moral power alone shall seem sufficient, but our standards of manhood and womanhood may be brought to include thorough wholesomeness physically, intellectually and morally, until one deficient in any of these respects shall be recognized as undesirable in marriage. When that time comes the steady pressure of this high ideal of what constitutes attractiveness in marriage will secure eugenic progress. I commend to you for study and careful thought this most keenly interesting subject of eugenics, far too great for any discussion in the few minutes still at our disposal. But in eugenics, I am convinced, lies the future of mankind, and the hope of his escape from the menace of degeneration through the luxury of wealth and ease. This, the newest of the sciences—the science of genetics—will yet show us how to control intelligently the development of mankind in order to reach the fullest realization of their possibilities. This is the science which will be dominant in the ultimate human society.

But this is a long look ahead. Thousands of years will be needed for the perfecting of mankind, even with the powerful aid of eugenic science. The present problem is to set all the nations of the earth upon the road of progress. The vision of the distant heights to be ultimately attained must not make us impatient of the plodding toil along the way. Let the vision rather inspire us to take intelligently the first steps and to continue steadfastly in the path.

The first thing is to introduce and then to cultivate the scientific spirit of search for truth, and to this end let us encourage all the arts and industries that bring us into daily contact with experimental science. Thus by doing the homely tasks of science we shall find the spirit of science entering our souls, this spirit which is the spirit of progress. Let us thus learn fearlessly to test all things, however sacred they may have become through long established custom, and let us with high resolve, hold fast to that which proves itself to be good.

THE NEW SCIENCE OF PLANT SOCIOLOGY

By Dr. ROLAND M. HARPER

COLLEGE POINT, MD.

SOME of the sciences dealing with mankind, such as anthropology, anatomy, physiology and sociology, are pretty closely paralleled by sciences dealing with the vegetable kingdom. Plant sociology (or phytosociology), the science of plant societies, or vegetation, is analogous in many ways to human sociology, the science of human society, or population. Although human sociology deals with only a single species, *Homo sapiens,* it classifies him according to occupations, forms of government, etc. Plant sociology differs in dealing with a multitude of species, but these may be grouped according to structure and adaptations, which are analogous to the qualifications and occupations of men.

A pioneer human society is chiefly made up of hunters, prospectors, cowboys, lumbermen and other resourceful but not highly educated people, while urban society is much more complex, and contains many notables and nobodies, specialists, dependents, idlers and parasites. Likewise a pioneer plant society may consist largely of lichens, mosses and other hardy forms, while in a dense "climax" forest there are tall trees and low herbs; vines and epiphytes, which depend on the trees for support; saprophytes or humus plants, which live on decayed leaves furnished by other plants; and often many parasites as well.

As has been the case with most other sciences, some of the foundations for the one under consideration were laid long before it was thought of as a distinct subject for study. A century and more ago a few observant travelers, even some without botanical training, were describing vegetation correctly though rather superficially; and some of the fundamental principles of the science have been known and used by foresters for several decades. But there is scarcely a hint of the sociological point of view in nineteenth century botanical text-books, classifications of vegetation did not begin to appear in botanical literature until about twenty years ago, and the term plant sociology itself is only about four years old.[1]

A few years ago plant sociology was partly confused with the almost equally new sciences of plant geography and ecology; and such terms as ecological plant geography, meaning the geography of plant associations, and synecology, meaning the relation of such associations to

[1] See *Torreya,* 16: 138, June, 1916. Readers who do not have access to botanical magazines can find a short article on the subject by the writer in the current edition of the New International Encyclopædia.

environment, are occasionally seen now. But geography deals primarily with distribution, ecology with environment, and sociology with association interrelations, three fundamentally distinct points of view. Like every other distinct science, plant sociology has laws peculiar to itself, as will be shown presently.

Probably the most obvious feature of vegetation, the world over, is that it is divisible into groups of more or less homogeneous aspect, such as forests, thickets, meadows, prairies, marshes and deserts. The first step in plant sociology therefore is to classify these vegetation types or associations; just as the early botanists, zoologists and mineralogists were occupied principally with classifying plants, animals and minerals. As a given type of vegetation is commonly correlated with a certain combination of soil, climate and other environmental factors, the first classifications of vegetation were primarily classifications of habitats; and it is indeed difficult to study vegetation without reference to its habitat.

The next step is to analyze each vegetation type. At first, say in the last decade of the nineteenth century, this was done by merely listing the species of plants in each habitat, in botanical or alphabetical or fortuitous order. But it is much more to the point to divide the plants into trees, shrubs, vines, evergreens, perennials, annuals, etc., regardless of their names or taxonomic relationships; though as yet there is little agreement among botanists as to the details of such a classification. It is also very important to determine the relative abundance of the different species or structural categories, for obviously a forest with more pines than oaks, or more shrubs than trees, has a different meaning from one in which the proportions are reversed.[2] For this sort of investigation demography, meaning the study of population, would probably be a better term than sociology, for in it the interrelations of the plants are not specially considered, and the study is static rather than dynamic.

It might be justly said that the demographic study of vegetation has hardly begun, even in the neighborhood of some of the greatest research centers, and there are thousands of square miles in nearly every state and country where we know at present practically nothing of the details of the vegetation, as distinguished from the flora. In the United States the greatest activity in this line has been manifested in and near the upper Mississippi Valley; and nearly all descriptions, photographs and maps of vegetation hitherto published for New England, New York, the south and the far west are the work of men born or trained elsewhere. (The reasons for this state of affairs are somewhat different in each case, and rather complex, and need not be discussed here.) The invention of the half-tone process, about thirty years ago, was a boon to the (then unknown) plant sociologist, for the possibility of making accurate

[2] See 6th Ann. Rep. Fla. Geol. Surv., pp. 175–177 (footnote), 1914.

reproductions of photographs at small expense greatly facilitates the study and comparison of vegetation types.

In dynamic plant sociology, as distinguished from demography, we are concerned among other things with the competition and cooperation between neighboring plants, or the struggle for existence; the rate of establishment and average longevity of the trees or other plants (either collectively or one species at a time), and the annual growth (absolute or relative) of wood, or of all vegetation, per unit area. Such studies, which are analogous to studies of the birth and death rate in human society, have already been pretty highly developed by foresters.

A most interesting phenomenon of plant sociology, which is going on everywhere all the time, but so slowly that it is not easy to observe or to experiment with, and was hardly thought of up to twenty years ago, is succession, which is the gradual replacement of one type of vegetation by another, with or without a concurrent fundamental change in environment.[3] Many botanists have exercised their imaginations by theorizing on this subject, but often with too slender a foundation of facts and therefore without getting definite and convincing results. When quantitative studies of vegetation become more universal, however, the study of succession will be on a more solid basis. One might as well try to discuss the movements of population in the United States without census statistics as to speculate on succession of vegetation without knowing the relative abundance of the species.

Another problem for the plant sociologist is to determine the normal frequency and effect of fire in each type of vegetation. Most people, even foresters, seem to regard forest and prairie fires as mere accidents, to be prevented if possible; but a few ecologists have already studied fire as a normal environmental factor. As fire does not attack scattered or isolated plants, of one species at a time, as a disease or other enemy might, but sweeps through the vegetation when conditions permit, its frequency and intensity depend mostly on the character of the vegetation, and are therefore sociological problems.[4]

The old question of why prairies are treeless, which has been much discussed by geologists, geographers, ecologists, etc., but never satisfactorily answered, is essentially a sociological problem, and perhaps it will be solved when sociological and demographic methods are brought to bear on it. A few of the other problems in plant sociology awaiting solution may be illustrated by the following questions, most of which

[3] The principles of succession have been pretty fully elaborated by Dr. H. C. Cowles in papers published in *The Botanical Gazette* in 1899, 1901 and 1911.

[4] See *Popular Science Monthly*, 85: 338 (footnote), October, 1914. The average forester to-day, probably largely on account of European traditions and teachings, seems to be almost as skeptical about forest fires being part of the natural order of things as the members of the Inquisition three centuries ago were toward Galileo's views about the movements of the earth.

deal with matters easily observed by persons who know nothing of botany. (A trained botanist can easily think of scores of others.)

Why are the tallest trees in a given forest usually all about the same height, regardless of species?

Where are the densest forests in the world? The fastest-growing?

What is the relation between the average distance one can see in a forest and the amount of timber per acre?

In the same climate which takes the most food and water from the soil: forest or prairie?

What keeps evergreen trees from growing in the richest soils, in the eastern United States?

Why are weeds detrimental to crops?

Why are prairie and pine-barren plants all or nearly all perennial?

If the climate became a little colder or warmer, wetter or drier, what plants would become more (or less) abundant?

Most of the sciences have one or more arts based on them, and this is true even of such a new science as plant sociology. Its most important application is in forestry. The forester deals with forests, the highest development of vegetation, in a natural or nearly natural condition, and it is therefore greatly to his advantage to know the laws governing the life of a forest, such as the amount of new wood being produced annually on different soils, the probable effect of cutting out some of the trees or underbrush, the normal frequency of fire, and the influence of insects, grazing animals, and other enemies.

The farmers who cut wild hay from the meadows and marshes of New England and the prairies of the west also have similar problems on a smaller scale, and if they know beforehand just what to expect in the long run from each type of meadow or prairie vegetation so much the better for them.

The art of agriculture has less to do with plant sociology and demography than with ecology. For the growth and yield of cultivated plants depends mainly on the environment and the care given them, but the manner in which they associate is determined artificially and has no particular significance. But weeds come in uninvited, and the effect of their competition is more or less of a sociological problem. And a knowledge of some of the principles of plant sociology is useful to settlers in a new region. The pioneer farmers who clear new land for the plow have long been accustomed to judging its fertility by means of the aspect of the vegetation on it, and if this rather empirical qualitative knowledge could be supplemented by a determination of the annual growth of vegetation much more definite correlations could be made. In a wooded region this would involve some difficulties, but in a prairie region it is as simple as measuring the yield of hay.

Lastly, by a study of the comparatively simple and obvious phe-

nomena of plant sociology one might get some valuable light on the analogous but more recondite problems of human sociology, and a clearer conception of its scope and subdivisions. Plants have the advantage of being fixed in one spot, and they show more delicate responses to environmental conditions and are more easily experimented with than human beings.

Although the opportunities for studying plant sociology are growing less every year with the encroachments of civilization on the forests, marshes and prairies, and some types of vegetation have already disappeared as completely as the Indian tribes of the eastern states, there are still several thousand acres of essentially natural vegetation even within the corporate limits of New York and Chicago, more remote regions are continually being made more accessible by the extension of transportation lines, and some areas of special interest are being set aside as national and state parks or forests, so that the new science is likely to have a healthy growth for some time to come.

MEMORIES OF THE SMITHSONIAN

BY DR. MARCUS BENJAMIN
U. S. NATIONAL MUSEUM

IN Simon Newcomb's "Reminiscences of an Astronomer" he tells of how he visited Washington in 1854 and then "speculated upon the possible object of a queer red sandstone building, which seemed so different from anything else, and heard for the first time of the Smithsonian Institution."

It was not long before Newcomb visited Secretary Henry, who received him "with characteristic urbanity, told me something of his own studies, and suggested that I might find something to do on the Coast Survey." This was the beginning of Newcomb's entrance into the "world of sweetness and light" that culminated in a career and reputation never surpassed by any American man of science.

Thus almost from the completion of the home of this famous institution it began its work "for the increase and diffusion of knowledge among men" which is given in the will of its founder as its particular mission.

The Smithsonian Institution came into existence by the Act passed by Congress and approved by President Polk on August 10, 1846. A building was soon considered necessary and in response to an invitation James Renwick, Jr., of New York City, submitted two designs, one of which in the style of architecture of the last half of the twelfth century, known as the Norman or Lombard was selected.

A site was chosen on the Mall to the west of Seventh Street and about where Tenth Sreet would cross the Park and on May 1, 1847, the corner stone of the new building was laid with imposing ceremonies, including Masonic rites.

The design originally consisted of a main center building two stories high and two wings of a single story connected by intervening ranges, each of the latter having on the north or principal front a cloister with open stone screen. Later the east wing was entirely rebuilt and the connecting range is now four stories high, so that the cloister has disappeared. On the west side the connecting range has been included so as to form part of the structure.

The building, as originally designed, contained provision for objects of natural history, thus at the beginning providing for a museum; archeological and mineralogical cabinet; a chemical laboratory and library; a gallery of art; and lecture rooms.

Two years later, in April, the east wing of the building was ready

for occupancy by the Secretary and his staff, and before the end of the year the west wing was also completed and was being temporarily fitted for occupation as a library.

Let us now return to the man who was the inspiration of the Smithsonian. When Professor Henry came from Princeton to Washington he settled with his family in a pleasant house on the southeast corner of E and Thirteenth Streets, but later the east wing of the Smithsonian building became his permanent home. He was gladly accepted as the foremost among the Washington men of science, and it soon became the pleasant practise of visiting scientists to call and pay their respects to him whenever they were in Washington. Many of these were younger men who came to have a filial affection for him whom they so justly regarded as the Nestor of American science. Two experiences of this character have come to me from friends, both of whom have since been called to fill important places in the scientific world. I venture to include them.

Dr. William McMurtrie, one of the early chemists in the Department of Agriculture, often told me of the happy evenings spent in the Smithsonian, when he was on one side of the table and Professor Henry on the other, discussing papers on chemistry to be used for insertion in the appendix of the Annual Reports. McMurtrie's final years were made less sad by a portrait of Henry that I was able to send him, and when I last saw him he had it framed and hung on the walls of his library among the great men he had known and loved.

When filling the chair of chemistry at the U. S. Naval Academy in Annapolis, Charles E. Munroe, now the senior dean of scientific studies in George Washington University, was always glad to spend a Sunday in Washington, so that he might enjoy the hospitality of the secretary and his family.

Doubtless there were many others; for when there are three young ladies in a family as well as a distinguished father, it becomes difficult to keep the young men away.

Then frequently there came to the Smithsonian Institution members of the Scientific Club, a unique organization that met every Saturday evening, except during the summer months, at the home of some one of its members, and which was essentially the parent of the now famous Cosmos Club of Washington. Among its members was Henry, of whom Hugh McCulloch wrote:

> Professor Henry was thoroughly American in his loyalty to the government; and in his admiration of our republican institutions, but in scientific pursuits he was a citizen of the world.

The other members included: Alexander Dallas Bache, a great-grandson of Benjamin Franklin and for many years superintendent of the Coast Survey; F. A. P. Barnard, then associated with the Coast Survey and later president of Columbia College in New York City; Benjamin N. Craig, of the Army Medical Museum; James M. Gilliss, an

astronomer of reputation who had charge of the Naval Observatory; J. E. Hilgard, then in the service of the Coast Survey, and later its superintendent; General A. A. Humphreys, a famous topographical engineer and later chief of his corps; Jonathan H. Lane, a wonderful mathematician, who lived a life of great usefulness to others but without achieving special distinction; Hugh McCulloch, comptroller of currency, and the secretary of the treasury during Lincoln's administration; General Montgomery C. Meigs, who possessed "vigilance, industry and integrity, with the ability to comprehend large transactions, and master the smallest details" which he demonstrated to a remarkable degree while in charge of the Quartermaster's department during the Civil War; Peter Parker, best known for his knowledge of the Chinese language and for his services to the government in aiding in the establishment of diplomatic relations with China; Titian H. Peale, an artist of recognized ability but associated with the work of the patent office; George C. Schaeffer, "a prodigy of learning" and long librarian of the patent office; and William B. Taylor, the editor of the Smithsonian publications and bibliographer of Henry. McCulloch says of them:

> There was not one who would not have been distinguished in any literary and scientific club in this country, or any other; there was not a money-worshipper or a time-server among them all.

In 1863 the National Academy of Sciences came into existence and its annual meetings have always been held in Washington during April. Bache was its first president and Henry was his successor. Among those named as members in the act of incorporation were Gilliss, Hilgard, Humphreys, Lane and Meigs who were connected with the Scientific Club. The meeting place of the academy was usually in the Smithsonian building, but no meeting was ever complete without the formal reception given by Secretary Henry. And what a splendid galaxy of men these were! There was the gracious and interested Agassiz, the kindly Gray, and the erudite Peirce from Harvard; the two Sillimans, father and son, and Dana, the geologist from Yale; nor should I omit Wolcott Gibbs, the great chemist, an alumnus of Columbia; nor Torrey, the botanist, nor the delightful Newberry, the paleontologist. These and many others graced with their charming personalities these social gatherings in the east wing of the Smithsonian.

The east wing of the Smithsonian Building was assigned to Secretary Henry "and his staff" as a dwelling place, but at that early date the "staff" does not appear to have been very large.

In 1847 Charles C. Jewitt was appointed assistant secretary and librarian, and remained as such until 1855, when he was separated from the institution in consequence of a disagreement of policy with Henry in regard to administration. His retirement has been referred to as representing "the culmination of a struggle between science and literature in which science prevailed."

Spencer Fullerton Baird came to the institution as assistant secretary in 1850 and continued in that capacity until 1878, when, on the death of Henry, he succeeded to the secretaryship, which he then held until his own death in 1887. Baird resided for a time on the corner of B and 10th Streets, south of the institution, but later had his home on the north side of Massachusetts Avenue, between 14th and 15th Streets. He does not appear to have ever lived in the Smithsonian itself, although his offices were for many years over the entrance of the north front of the main building.

Baird will always be remembered on account of his remarkable influence upon young naturalists. John S. Billings, the veteran librarian, said:

> Such work as was done by Professor Baird in this direction gives a starting point to many observers and investigators in different localities, stimulates further inquiry, and when done on the extensive scale on which he did it, based on the examination and comparison of a large number of specimens from widely different localities, exercises a powerful influence for years to come in lines of exploration, collection and critical research.

Doctor Billings was indeed right; for the influence of Baird is ever with us, and it is seldom that any important volume on natural history is issued by the Smithsonian or the National Museum without reference to this fact. Let me quote in part Robert Ridgway's dedication to Baird which appears in the first volume of his monumental "Birds of North and Middle America," the sixth part of which has just been published.

> Dedicated to the memory of Spencer Fullerton Baird, America's first and best systematic ornithologist, whose guiding principle "What is worth doing is worth doing well" is evident through all his work; who labored for the advancement of science, not for fame.

Mention must be made, even if brief, of William J. Rhees, who was chief clerk during the administration of Henry, Baird and Langley. Yielding, however, to advancing years during the incumbency of the last-named, he became archivist and occupied his closing years in the preparation and publication of the two volumes entitled "Documents Relative to the Origin and History of the Smithsonian Institution." He came to the Institution in 1852 and died in its service fifty-five years later. He was long the senior of us all, and to his wonderful memory I am indebted for many of the reminiscences of the institution that are here given. It is much to be regretted that no time was ever found to place on record those memories which were lost forever when he yielded to that summons from which there is no recall. His deep devotion to the institution he loved so well was evidenced by a bequest from his modest estate.

About the middle of the last century there were two great masters who in this country exerted a tremendous influence upon young men,

THE SMITHSONIAN INSTITUTION.

leading them to the study of natural science. These were Agassiz and Baird. The influence of Agassiz survives in that wonderful assemblage of pupils that included not only his own son Alexander, but also Alphaeus Hyatt, David Starr Jordan, E. S. Morse, A. S. Packard, F. W. Putnam, S. H. Scudder, A. E. Verrill and many others. Baird's influence was equally potent and many of his students came to the institution and for a time occupied the tower-rooms of the main building so that they might be always near him to profit by his instruction.

JOSEPH HENRY.

The names of many of these young naturalists who came to the Smithsonian have been forgotten, but fortunately some of them may be

recalled by the following stanza, improvised by one of their number, after a hotly contested argument on some disputed point in natural history:

Into this well of learning dip with spoon of Wood or Horn
For students Meek and holy silver spoons should treat with scorn.
If Gabb should have the gift of Gill
As Gill has gift of Gabb,
'Twould show a want of judgment still
To try to Cope with Meek.

Egleston, the mineralogist; Dall, the conchologist; and Ridgway, the ornithologist, may also be included among those who for a time were tenants of the tower-rooms.

Cope, Dall, Gabb, Gill and Meek became members of the National Academy, which is distinct evidence of the high esteem with which their investigations were regarded by their contemporaries.

Somewhere in his "Life of Lincoln" John Hay tells an amusing story of the tower-dwellers which is not denied by Gill, who was long the only survivor of the war-period.

It appears that one evening when Secretary Henry was busily engaged at the White House with President Lincoln discussing in all probability the scientific features of some one of the many inventions that were submitted to the government authorities either for the improvement of war conditions or for increasing their severity, a visitor appeared who somewhat excitedly insisted on seeing the president at once. He was ushered into the room, and on expressing his desire for a private interview, was assured by Mr. Lincoln that his guest was a loyal Union man. The trouble was soon disclosed; for the stranger broke out into a violent harangue on the treasonable proceedings that had been going on at the Smithsonian Institution. The President promptly replied: "We will have to look into this, and it is fortunate that Professor Henry is here with us to hear your story."

It appeared that every night at a given hour lights appeared in one of the rooms of the South Tower and the shifting of these lights was interpreted as signals by means of which the traitor in the Smithsonian was conveying information to the enemy whose representatives were stationed on the hills in Virginia opposite Washington. The matter was however promptly investigated by Secretary Henry, who was soon able to report that the phenomena of lights was due to the early return of Professor Gill to his room where every evening he devoted his time to the study of the specimens that were assigned to him to report upon.

Gill was the last of the "old guard" and notwithstanding his advancing years he came almost daily to the old building where he gladly gave of his time and knowledge to those who were in search of truth.

His visit to Scotland in 1906 was a great event in his life and he

SPENCER F. BAIRD.

represented some scientific body at the four-hundredth anniversary of the founding of the University of Aberdeen. One Sunday morning when about to enter the local church he was stopped by one of the deacons and asked the strange question: "Are you a Christian?" Not quite prepared for such an interrogation, and perhaps not hearing the words clearly, but realizing that an answer was necessary, he promptly said: "No, I am an American." To which came the response: "Oh, very well, you may go in."

No respectable building of any antiquity, I suppose, can exist without sooner or later having its ghost story. The Smithsonian is no exception to the rule, and for a time tales were in circulation of the white figure that was seen moving rapidly about the halls. Finally, the servants in the secretary's family reported having seen the "ghost" on several occasions at dawn. The matter was soon cleared up; for it was found that a distinguished English scientist who was studying one of the collections was in the habit after taking his cold "tub" of enveloping himself in a sheet and running about in that scanty attire on cold mornings to restore his circulation, a practise which it is almost needless to say he promptly discontinued when his attention was called to the unfortunate notoriety that he was giving to the building.

Doubtless because of the skeletons and bones of strange animals that claimed the attention of some of the scientists who reported on the specimens that came to the Smithsonian from the early trans-continental surveys the institution came to be regarded as haunted. This was especially true in the case with the colored people, whose superstitious

natures made them so fearful of the innocent building that they could not be induced to pass the door after sundown.

It is said that on one occasion a colored man who was seeking employment was hired by an official of the Smithsonian and on being told to report to the institution, became so frightened that he ran away and could not be found for two weeks.

The main portion of the Smithsonian building was two stories high, each of which contained a large hall. The one on the lower story was not occupied at first, but it was here that as early as 1856 there was on daily exhibition a large map showing the condition of the weather over a considerable portion of the United States. Every morning reports were received by telegraph, telling of the changes that had occurred and these were then indicated on the map by pieces of card-board of different colors serving to denote different conditions of the weather as to clearness, cloudiness, rain or snow. It is interesting to add that Professor Henry said:

> This map is not only of interest to visitors in exhibiting the kind of weather which their friends are experiencing, but is also of importance in determining at a glance the probable changes which may soon be expected.

THEO. GILL.

Thus it was that the Smithsonian Institution was the first in the world to organize a comprehensive system of telegraphic meteorology and gave to the world as Cleveland Abbe describes it "that most beneficent natural application of modern science, the storm warnings." It was indeed the beginning of the Weather Bureau service.

The civil war interrupted the continuance of this service and the hall was assigned to the exhibition

SAMUEL P. LANGLEY.

of museum specimens, principally the bird collections. With the removal of these to the newer building of the National Museum, part of the ever-growing library has been installed there.

On the upper floor was the large lecture room, capable of holding two thousand persons and there every winter courses of popular scientific lectures were delivered by masters in their specialties. To them the public of Washington was cordially invited and gladly came. It was at one of these, presided over by the venerable George Washington Parke Custis, that Otis T. Mason received his first inspiration to devote his attention to American anthropology, on which subject he afterwards became a recognized authority, and at the time of his death in 1908 was head curator of anthropology in the National Museum. This hall was given up later to the exhibition of the collections in prehistoric archeology and now contains the enormous collection of plants that constitutes the National Herbarium.

The west wing of the Smithsonian has often been called the chapel, owing perhaps to the square tower and apse that are on the north side. It was originally used as a library, but the increasing volume of books

CHARLES D. WALCOTT.

that poured in soon made other arrangements necessary. For a time the collections of marine invertebrates were installed there, but since these collections were transferred to the larger building it has not been permanently occupied.

From the fact that Greenough's statue of Washington that so long stood exposed to the elements on the east front of the capitol has found a resting place in this wing its use as a gallery for sculpture has been suggested.

During the summer before last it served a sacred purpose and so was consecrated anew by loving and competent hands to the restoration of the original Star-spangled Banner that floated over Fort McHenry just a century ago, and inspired the immortal words of Francis Scott Key.

After the death of Henry the offices of administration were grouped

in the east wing and business became the dominant feature of that end of the building. Thereafter functions were usually given in the larger buildings of the National Museum. It is, however, of interest to remember that the workshops in which Secretary Langley constructed the machinery for the aerodrome with which he showed the practicability of aerial navigation were on the upper floor. That the trial of his machine was not altogether a success broke the heart of Langley, and he never was the same after that unfortunate experience.

John A. Brashear, a life-long friend, tells the following pathetic account of his last visit to Langley. He says:

> I can not forget the last half-hour I spent in his office in the Smithsonian Institution, where I had so many pleasant talks with him in past years. He showed me the little piece of apparatus that had broken, deflecting the aerodrome into the Potomac, whereas it should have sailed up into the air. With a sad heart he turned to me and with trembling voice said, "Mr. Brashear, this has wrecked my hopes forever. My life work is a failure." I did all in my power to cheer and comfort him, but it was too late.

The world failed at first to appreciate the value of Langley's demonstration, and he died without realizing the enormous value of his great contribution to science. During the summer of 1914 Glenn H. Curtiss has demonstrated on Lake Keuka in New York with Langley's original machine its absolute power of flying, thus establishing beyond every possible dispute that Langley's aerodrome represented "a clear triumph for pure inductive science." He was the first to demonstrate that powerful machines heavier than the air itself could be built to navigate the air.

The present secretary, Charles D. Walcott, now occupies the rooms of Langley's workshop with his laboratory, and there he devotes the time that he can spare from his administrative duties to the study of the Cambrian fauna, finding feet for wandering trilobites and furnishing eyes to those curious brachiopods that swam in the seas of that prehistoric long ago.

THE PROGRESS OF SCIENCE

BOOK OF THE OPENING OF THE RICE INSTITUTE

There have been issued from the De Vinne Press three sumptuous volumes commemorating the academic festival held in celebration of the formal opening of the Rice Institute, which occurred on the tenth and twelfth of October, 1912. There has already been given in this journal some account of the institute founded in Houston, Texas, by William R. Rice, and dedicated by him to the advancement of letters, science and art. The volumes which have now been published give a detailed account of the opening of the institute and the text of the inaugural lectures given by distinguished foreign men of science. The volumes are by special permission inscribed to the "thirteenth president of Princeton University and the twenty-eighth president of the United States." The ceremonials which they describe were among the last of international gatherings.

In his dedicatory address, Dr. Edgar O. Lovett, the president of the institute, gives a full account of its foundation and its objects. During his lifetime Mr. Rice gave considerable sums to a board of trustees organized to administer the foundation and made the new foundation his residuary legatee. After a long litigation following his death, the institution was in possession of an estate whose present value is estimated at not less than ten million dollars. The institute secured a campus of 300 acres three miles from the center of the city, and a general architectural plan designed by Mr. R. A. Cram was accepted by the board in the spring of 1910. The Rice Institute plans to be a university of the highest standing, including in its scope science, letters and art. It is said that at the outset art is to be recognized by the architecture and physical setting of the buildings. The teaching and research are divided into three divisions, science, humanity and technology, and it is the aim of the institution to achieve its widest claims to distinction in those regions of inquiry and investigation where the methods of modern science are more directly applicable. There are erected in the building three marble tablets to letters, art and science, the last bearing the profile of Isaac Newton and Job's anticipation of the method of scientific inquiry, "Speak to the earth and it shall teach thee!" On the granite columns of the cloister appear the heads of sixteen leaders, of whom ten are in science. They are: Medicine, Pasteur; Engineering, De Lesseps; Mathematics, Lie; Physics, Kelvin; Chemistry, Mendeleef; Biology, Darwin; Electric Oscillations, Hertz; Aerodynamics, Langley; Radioactivity, Curie; Eugenics, Galton.

The main part of the volumes is taken up by the addresses of twelve distinguished foreign delegates, each of whom gave from one to four lectures. The death of Henri Poincaré prevented his giving the promised lectures on the philosophy of science; a memoir on his life and work was presented by Professor Volterra. Excellent portraits are given of the lecturers, several of which are here reproduced, and tablets were erected in commemoration of their presence at the opening exercises. The inscriptions on the tablets for the seven scientific men are as follows:

Professor Emile Borel, of Paris, France: director of scientific studies at the Ecole Normale Supérieure; Editor-in-chief of *La Revue du Mois;* professor of the theory of functions at the University of Paris; successful in the discharge of exacting duties as admin-

Hugo de Vries

istrator, educator and editor, his studies in mathematical analysis worthily maintain the standards of scientific work established by the historic line of French analysts extending from Lagrange and Laplace to Hermite and Poincaré.

Professor Hugo de Vries, of Amsterdam, Holland: director of the Hortus Botanicus and professor of the anatomy and physiology of plants in the University of Amsterdam; a careful observer and patient investigator of the phenomena of growth and change in living things, whose studies and experiments of a quarter of a century have resulted in capital contributions to the theories of heredity and the origin of species.

Privy Councilor Professor Wilhelm Ostwald, of Gross-Bothen, Germany: late professor of chemistry in the University of Leipsic; Nobel Laureate in Chemistry, 1909; a versatile man of science whose interests and activities range from art through letters into metaphysics, he is justly celebrated as one of the founders of physical chemistry and equally well known as the chief propagandist of a new natural philosophy based on the theories of energetics.

The late Professor Henri Poincaré, of Paris, France: Member of the French Academy; Commander of the Legion of Honor; professor of mathematics and astronomy at the University of Paris; distinguished for discoveries of far-reaching significance in pure mathematics, celestial mechanics and mathematical physics, a varied intellectual activity of extraordinary fertility has secured for him a place of eminence in letters, in science and in philosophy.

Professor Sir William Ramsay, K.C.B., of London, England: late professor of chemistry at University College, London; Nobel Laureate in Chemistry, 1904; president of the Seventh International Congress of Applied Chemistry; a facile experimenter of boldness and ingenuity, who has devised new theories and revived outworn ones in a series of remarkable achievements which of themselves constitute an epoch in the history of the chemical elements and a permanent chapter in the annals of science.

Professor Carl Størmer, of Christiania, Norway: Member of the Norwegian Academy of Sciences; associate editor of the *Acta Mathematica;* professor of pure mathematics in the University of Christiania; professorial successor of the illustrious Norse geometer, Marius Sophus Lie, and himself a master of the methods of reckoning who has drawn from the equations of mechanics a new theory of terrestrial magnetism revealing new explanations of the lights of the northern skies and kindred manifestations in the solar system.

Professor Vito Volterra, of Rome, Italy: life senator of the Italian Kingdom; dean of the faculty of science and professor of mathematical physics and celestial mechanics in the University of Rome; recently lecturer in the universities of Paris and Stockholm; an analyst of rare skill whose theories have found manifold applications both in pure and in applied science, he has served his country even more directly as an able organizer of educational and scientific undertakings national in scope and international in influence.

IMPORTED AND NATIVE WOODS USED FOR DYE MATERIALS

THE New York State College of Forestry at Syracuse is investigating the importation and use of foreign dye woods and the recent use of certain native species for dye wood purposes. The college is receiving many inquiries about the use of various woods for dye purposes and the investigation is being carried out to meet these inquiries.

The English blockade of all German exports as a phase of the great war, has prevented the importation of the well-known German aniline dyes. To meet this situation, the importation of foreign dye woods has been greatly stimulated. Along with this use of foreign dye woods is the increased use of the native osage orange for native colors.

Poincaré

In 1915 over 68,000 tons of dye woods valued at over $1,000,000, were imported into this country. In the year 1916 it is estimated that there will be a large increase in both quantity and value. Logwood is the most widely used dye wood that is brought into the country. During the year 1915, of the total amount it made up over 55,000 tons valued at $742,000. The pieces of wood as imported vary in diameter from 4 inches up to 3 feet or more and about 20 to 25 pieces on the average make a ton. A good share of this wood comes from Mexico. It is estimated that there are over 1,000 tons of logwood on the piers in New York harbor at the present time. In fact there has been such a demand for foreign dye woods that it has tended to stimulate production resulting in considerable speculation.

Owing to the tremendous demand for shipping facilities to carry war munitions, food and other supplies to the warring nations in Europe, the prices for transporting dye wood have been the principal cause for the great increase in the prices for these dye wood materials. For example, logwood before the war was normally sold for about $19 per long ton. The present price is around $50 per long ton. Before the war fustic brought a price of $19 per long ton and now brings $40. Lima or Brazil formerly brought $25 and now is worth $40. The price of osage orange has remained about the same, namely $15 per long ton delivered. In fact all of these prices are given as delivered on the docks in New York harbor. The transportation charges are commonly quoted at from $22 to $28 a ton from West Indian and Mexican ports to the Atlantic seaboard.

Beside logwood, the principal woods are fustic, Lima wood or Brazil wood and a few other woods of lesser importance. Osage orange, which is found chiefly in eastern Oklahoma, Kansas, Arkansas and Missouri, as well as throughout the lower Mississippi valley, is coming into considerable prominence in the dye wood trade.

Dye woods have been brought to this country for the past 200 years. One New York company has been importing them for 115 years. Logwood which probably makes up 80 per cent. of all the wood used for dye purposes, is used for blue and black colors. Fustic and osage orange are used for the yellows and the Brazil wood is used for red. For other colors blends between these are used. The dye wood extract manufacturers require that the wood be completely stripped of all bark and sap wood. In fact the heart wood of the trees is the only portion that contains sufficient dyeing material to justify the expensive transportation charges involved. The trade generally considers that the outlook for osage orange is not particularly bright, for the reason that there is a sufficiently large supply of other and better dyeing material available.

FIGHTING AUSTRALIAN APHIDS WITH MAINE FLIES

An interesting situation in international entomology has recently developed with reference to the modern practise of introducing, from one country to another, an insect control of an insect pest. The spectacular success of the Australian lady-beetle against the fluted scale of citrus fruits in California; the slower, more complex but effective work of imported parasitic and predaceous enemies against the brown-tail and gypsy moths in New England; and other experiments of this nature varying in importance; are already matters of economic history.

Up to this time few, if any, attempts have been made, in this connection, to distribute the Syrphidæ, a family of flies (Diptera) many of which are, in their larval stages, predaceous upon aphids. It has been well known, of course, that this habit is of real economic importance, but it has apparently been customary to relegate these flies to a position of second importance in this field of useful endeavor and to confer first honors to the lady-beetles and parasitic Hymenoptera.

Vito Volterra

Observations of some ten or twelve years in Maine, however, indicated strongly that the syrphid larvæ are, in that locality, the most efficient natural enemies of the aphids. In accordance, therefore, with the entomological policy of the Maine Agricultural Experiment Station to solicit the cooperation of specialists for problems of prime importance, Professor C. L. Metcalf was invited to study the Syrphidæ of that state with particular reference to their larval habits.

Significant data were thus secured concerning which species of syrphids feed upon a given species of aphid. The publication, in bulletin form, of this and related information included the statement that a certain syrphid, *Pipiza pisticoides*, plays in the vicinity of Orono a rôle of first importance as a natural enemy of the woolly aphid of the apple. The larvæ feed so abundantly that the above ground colonies of this pest are well nigh exterminated by late summer.

Following upon this announcement a request came from Perth, Western Australia, for an importation of these flies in consideration of the fact that the woolly aphid is the most serious apple pest in that state. Accordingly, plans are underway for the shipment of *Pipiza pisticoides* and possibly other syrphids which accept the same diet.

It is never safe to predict results in an experiment of this sort, but the indications are in favor of a successful outcome. In which case the nice exchange of international courtesies—apples in Australia for oranges in America through benefit by insects—is of scientific as well as agricultural interest.

SCIENTIFIC ITEMS

We record with regret the death of Professor Emil von Behring, of the University of Marburg, discoverer of diphtheria antitoxin; of Professor J. G. Darboux, permanent secretary of the Paris Academy of Sciences and professor of mathematics at the Sorbonne; of George Massee, for many years head of the cryptogamic department of the Herbarium of the Kew Gardens, distinguished for his work in mycology; of M. Jules Courmont, professor of hygiene at Lyons; of G. Paladino, professor of histology and general physiology at the University of Naples, senator of the realm, and of General J. A. L. Bassot, the distinguished French geodesist.

Dr. Alexander Graham Bell, inventor of the telephone, was awarded the Civic Forum Gold Medal for distinguished public service in New York on March 21. The presentation address was made by Dr. John H. Finley, state commissioner of education. Dr. Bell is the third recipient of the medal. It was awarded to Major General George W. Goethals in 1914, and to Thomas A. Edison in 1915.

Sir J. J. Thomson, Cavendish professor of physics at the University of Cambridge and president of the Royal Society, Sir David Prain, director of Kew Botanical Gardens, and Sir George Beilby, head of the Royal Technical College of Glasgow, have been elected trustees of the Carnegie Trust for Scottish Universities.

Mrs. Stephen V. Harkness has given to Yale University funds to erect dormitories for the use of students of the college in the form of one or more quadrangles. It is said that the value of Mrs. Harkness's gift may exceed five million dollars.

It is reported that the Rockefeller Institute for Medical Research has appropriated $200,000 for the establishment of a hospital to be used for the instruction of surgeons in the Carrel-Dakin treatment of the wounded. It is expected that Dr. Alexis Carrel will be granted a leave of absence from France to return to New York and assume supervision of the work.

Vol. 4, No. 6 JUNE, 1917

THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: SUB-STATION 84

SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION, $3.00

THE SCIENTIFIC MONTHLY

JUNE, 1917

A PILGRIMAGE TO THE HOME OF CONFUCIUS[1]

By WALTER K. FISHER
STANFORD UNIVERSITY, CALIFORNIA

THE fatherland of Confucius was a comparatively small kingdom called Lu, which occupied most of the southern half of the present province of Shantung. Tai Shan, the sacred mountain, stands near the northern border. Chufu, the birthplace of the sage, and where he was buried in 478 B.C., is about sixty miles south of the mountain, and nearly an equal distance southwest of the center of the ancient kingdom.

Shantung is called the Cradle of China. The Chinese really came from the west through the valley of the Yellow River, and, driving out or absorbing the original inhabitants, settled in the "region east of the mountains" (Shantung), whence they gradually extended their sway. The province has, therefore, been regarded as the home of the Chinese race. It gave to China its two greatest sages, Confucius and Mencius. Yao and Shun, the two heroes of China's Golden Age, worshiped on Tai Shan.

The Shantung men are stalwart and vigorous, with a reputation for turbulence and violence. In the province, the sturdy farmer thrives and looks upon his ancestral fields as sacred. Small holdings are the rule, and are cultivated with great care, for the population is dense. In the less fertile regions the struggle for a livelihood has become severe. Much of Shantung is mountainous, or unproductive, so that the great fertile plains are all the more crowded. In these congested districts a single bad year brings misery to multitudes of people, who migrate south on foot, or flock to the towns and cities and are supplied by the magistrates with a bowl of millet each, per day. In addition to famines caused by ordinary crop shortage must be added the havoc wrought by the chronic floods of the Yellow River and other streams.

The old walled town of Chufu is about six miles east of the Tientsin–Pukow railway, and prior to the revolution was governed by a direct descendant of Confucius (K'ung Foo-tsze) of the seventy-fifth generation. He was a duke under the Manchu empire, and was regarded as

[1] With photographs by the author.

We rattled and bounced to Chufu from the nearest station in stout, covered, two-wheeled carts, each drawn by a couple of stocky mules, hitched tandem. We were supposed to recline upon the floor, which, fastened directly to the axle-tree, magnified the inequalities of the lanes. The Chinese inverted sense of fitness applies to most rural roads. They are not publicly owned. In order to sacrifice as little of the precious land as possible, the farmers cause the road to meander the boundaries between two farms, so that one may travel very indirectly toward his goal. By constant packing and scraping of wheels, the way becomes worn below the fields, and during the rainy season serves as a

THE GRAVE OF CONFUCIUS.

Back of the altar is the mound upon which several small trees are growing. This grave with a few others are within a special enclosure. The very grass is sacred and endowed with powers of divination. The grave has been enlarged by handfuls of earth deposited by reverent pilgrims. Confucius was buried here in 479 B.C.

watercourse, to its further detriment. Then, being private property, the owner may draw upon it for supplies of soil to repair gullied gardens. On the whole, the road is a despised outcast, and although of necessity used by every one, it does not occur to the bucolic mind to accomplish any general repairs for such an impersonal quantity as the public. Dirt is far too valuable to be so wasted. As a consequence, although this particular road was exceptionally good, we had little opportunity for reflection.

Something like a mile from Chufu, a high plastered wall surrounds the most hallowed soil of China—a shaded park of many acres, where for nearly twenty-four centuries has rested the greatest of China's sons. We skirted the wall for a little distance, then entered a dreary hamlet, which, like a ragged beggar, displayed its poverty at the portals of the

THE GRAVE OF CONFUCIUS.

The mound is to the right of the monument which is in the center. The stone on the extreme right marks the grave of Confucius' son. On the left can be seen a portion of the chapel which stands on the site of a tiny lodge where Tze-Kung, a devoted disciple, watched for six years after the death of the Sage.

TEMPLE OF CONFUCIUS, CHUFU, SHANTUNG.

It consists of a long hall rising in one story to a great height. The pillars, of a yellowish-white stone, are wonderfully sculptured with dragons, and when tapped give forth a metallic ring. These, with the balustrades and gargoyles, at a distance remind one of huge pieces of carved ivory. Above, the eaves, are intricately formed and variously tinted.

sacred precincts. Beyond the main entrance, as I remember, there is a pailow or honorary gateway, in front of an arched stone bridge over a watercourse, then dry. From this, a short avenue conducted us to another gate, at the right of which, surrounding a sort of rectangle, were several houses, used for guests and also as the dwellings of the guardians. We next entered a cypress-shaded walk flanked by two pairs of huge stone dogs and ending at a third substantial gate-way in front of which stood two stone figures, one a soldier, the other a sage, with a great urn between them. This gate gives entrance to an inner walled enclosure of a few acres, whose oaks, in bright autumn russet and yellow, relieved the somber hues of numerous venerable cypresses. We sauntered along a straight path for a short distance, and turning to the left presently found ourselves before the grave of Confucius, a mound upon which grow several small oaks. Its simplicity is very impressive. On a paved area in front of the hillock is a narrow stone table or altar supporting an upright inscribed slab of gray stone carved at the top, after the manner of memorial tablets in China. This is about all that art has supplied, unless we include a little chapel, hard by, which marks the site of a tiny lodge where Tze-Kung, a devoted disciple, watched for six years after the death of the master. Next to the grave of Confucius is that of his son, while scattered about the enclosure are others of minor interest. Three ornate chapels with inscribed tablets commemorate the pilgrimages of bygone emperors. The very grass that grows within this enclosure is sacred, endowed with powers of divination much beyond what we attribute to witch-hazel.

dynamic violence of a mountain torrent. For, when the sage was laid to rest, Rome was an infant in arms, Socrates was not yet born, and Greece had not attained the Golden Age of Pericles. Yet, like those tufts of twigs which the spring freshets leave high and dry for autumn to wonder at, so in this sheltered bay the vernal flood of years has left a snag of cypress wood. It is just an old dry stump, held together by a band of iron. A tablet reverently pictures its form during life, and records its death, at the age of one thousand years, in the time of Charlemagne. Yet when this tree was a seedling, Confucius had been dead three hundred years—about the length of time since the Pilgrim Fathers landed in New England.

Outside this inner yard, but within the high wall, is a great host of tablets and mounds of seventy-five generations of the K'ung Foo-tsze

THE BIOGRAPHY OF CONFUCIUS ON STONE.

A fairly large hall at the rear of all the buildings contains a long barrier of polished stone, divided into rectangles whereon is pictured the life of Confucius with accompanying text. Although countless tracings have been made, the inscriptions are mostly still quite clear. These copies are made by placing moistened paper over the inscription, and then brushing over it an inky black paint, which leaves the characters white.

family, luxuriating, among scattered oaks and cypresses, in a wilderness of grass and weeds—a strange sight, this, in a country where everything inflammable is eagerly seized for fuel. The park is a veritable oasis in the rather dreary plain, and a haven of refuge for crows and other birds.

Chufu, which contains the finest Confucian temple in China, is really a big village. It is in the form of a rectangle about a mile in length by half a mile in breadth. One end of the enclosure is occupied

ONE OF THE NUMEROUS INSCRIBED MONUMENTS IN FRONT OF THE TEMPLE OF CONFUCIUS.

In the great court in front of the temple is a forest of stone slabs closely covered with inscriptions. Each monument was erected by a sovereign of the Empire, some of them dating back from 15 to 20 centuries. The great stones frequently rise from the backs of equally huge tortoises. Some of the monuments are protected by pavilions.

by the temple, which is connected with the burial ground by an avenue, overarched by stately cedars and adorned by two splendid marble pailows, one of three spans and one of five. This avenue is called the Shen Tao (the Spirit Road), meaning that the spirit of the holy man passes through these trees back and forth between tomb and temple. The temple is really a sort of vestibule to the tomb.

We drove about a mile through a choking dust to Chufu, but alongside the Shen Tao, because the avenue itself had become impassable through long neglect. The great temple and associated halls and courts are in a walled inclosure. The principal shrine resembles the Confucian temple at Peking but is vaster. Like all of its kind it consists of a long hall rising in one story to a great height. The pillars, of a yellowish white stone, are wonderfully sculptured with dragons, and when tapped give forth a metallic ring. These, with the balustrades and gargoyles, at a distance remind one of huge pieces of carved ivory. Above, the eaves are intricately formed and variously tinted as in most Chinese temples. Inside is a large figure of Confucius seated within a sort of recess elaborately decorated. Some of the principal disciples

AN INN YARD, CHUFU.

To the left is a group around an itinerant tinker. Note the cage in the tree. The Chinese are very fond of birds. The well is beneath the cage. The guest rooms, with no more furnishing than sleeping platforms, are at the rear.

are represented by statues of stone also, while numerous ancient bronze vases and elephants, and large yellow porcelain vases seem to be added in a spirit of decoration. Elsewhere, as a rule, the sage and his disciples are represented only by tablets inscribed with their names. The tablet in front of the statue of Confucius bears on it the inscription: "The seat of the spirit of the most holy ancient sage Confucius." Pendant from the vaulted roof are numerous gilded tablets setting forth the virtues of the sage. Tablets of seventy-two out of his three thousand disciples, who became conspicuous for wisdom and virtue, are ranged on either hand each in a separate shrine. In niches around the walls

A TYPICAL STREET IN CHUFU.

The houses are mostly of bricks plastered. Some are thatched and a few have tile roofs. One and all are most cheerless and uninviting. The streets are unpaved.

AN OX-CART IN CHUFU.

Away from the railroads, which are few, there is nothing in China which resembles rapid transit. Grain and other foodstuffs are transported to the rivers by ox-carts, or mule-carts, sometimes by wheelbarrows, and then freighted on slow-moving boats. In north China and Mongolia camels are much in vogue, and trains of pack-donkeys are a common sight.

are to be seen tablets of some of his eminent followers of later times. A cloud of incense fills the great chamber. Separated from this building by shaded courts are several other less pretentious temples. In these the two central pillars of the façade are sculptured in deep relief, while the laterals are engraved with flowers in graceful design, the peony being easily recognizable—all elaborately and beautifully executed. One of these temples is devoted to the memory of the father of Confucius, and another is sacred to the "Holy Mother," who trained and taught the Sage. The shrine to his wife (whom he is said to have divorced) is a simple tablet in a recess at the back of a special building. A fairly large hall at the rear of all the buildings contains a long

A PEDDLER AND HIS WHEELBARROW.

This man sells all sorts of small jars and earthen pots, some of which are supported on sticks in order to display them. The one-wheeled barrow is a very characteristic vehicle in China and unbelievable loads are carried on them.

barrier of polished stone, divided into rectangles whereon is pictured the life of Confucius with accompanying text. Facsimiles of this in book form are offered for sale by the priests. Although countless tracings have been made the inscriptions are mostly still quite clear. These copies are made by placing moistened paper over the inscription, rubbing it flat, and then brushing over it an inky black paint—probably manufactured from lamp-black. The paper sinks into the inscriptions and remains untouched, the characters thus appearing white against a black ground. In a fore court of the temple tracings were being made

from large tablets by men who worked with the abandon of a bill poster and left a goodly amount of the pigment on the stone.

In this great court in front of the temple is a forest of stone slabs, or columns, usually closely covered with inscriptions, and sometimes protected by a roof or pavilion. Each monument was erected by a sovereign of the empire, some of them dating back from fifteen to twenty centuries. The monolith is generally elaborately carved at the top and is borne on the back of a huge tortoise which shows a set of upper teeth with two projecting canines. An inscription by the Emperor Cheng Hua, 1465, refers to Confucius as "the Heart of Heaven without whom we should have been wrapped in one unbroken night."

Although he has a temple in every city, Confucius is not deified; he is never invoked in the character of a tutelar divinity. The homage paid him is purely commemorative. Confucius was not an originator; he was a reformer, selecting from the past and present whatever he deemed worthy of preservation. "I am not an author, but an editor," he said of himself. In this way, without assuming the rôle of a prophet, he gave to China a cult that reaches all classes, and a code of morals, which, however deficient in depth and power, still serves as a bond of social order. . . . Questioned as to a future life, he declined to dogmatize or speculate. "We know not life; how can we know death?" was his cautious answer. Yet he enjoined the worship of ancestors, a cult which has done more than any abstract teaching to cherish a belief in the survival of the soul.

A PRIMITIVE MILL, CHUFU.

The mill consists of a beveled roller which is pivoted to the center of a large flat circular stone, upon which the corn is spread. The donkey is blindfolded and is hitched to the roller. These mills are among the most characteristic features of villages in the north of China. Beyond the distant house may be seen the city wall.

A SMALL VILLAGE NEAR CHUFU, SHANTUNG.

This view was taken from the top of the mud wall surrounding the village and gives a good idea of a small Shantung town. The woman back of the house is splitting canes. These are first rolled with heavy stone rollers on hard ground, and are used for baskets, fences, etc.

The state religion[2] is not Confucianism, though founded on it. To the worship of Heaven it adds the worship of nature in its chief material forms, such as the earth, sun, moon, and stars, mountains and rivers. To the cultus of ancestors it not only adds that of heroes, but expands so as to take in many of the divinities of Taoism and Buddhism, thus forming a compound of the three religions. Logically the three are irreconcilable, the Taoist being materialism, the Buddhist idealism, and the Confucian essentially ethical. Yet the people, like the state, make of them a unity by swallowing portions of each. In ordinary their lives are regulated by Confucian forms, in sickness they call in Taoist priests to exorcise evil spirits, and at funerals they have Buddhist priests to say masses for the repose of the soul. Besides the women and the priesthood the two sects last named have very few professed adherents, though the whole nation is more or less tinged by them. The men (at least those who can read) almost without exception profess to be followers of Confucius.[3]

[2] That is, under the Empire; but it has really not changed.
[3] W. P. A. Martin, "A Cycle of Cathay," 1900, p. 288.

DEMONOLOGY AND BACTERIOLOGY IN MEDICINE

By JONATHAN WRIGHT, M.D.

PLEASANTVILLE, NEW YORK

IN the study of the theories of primitive medicine as set forth by the observers of modern uncivilized tribes and by the archeologists, the student is impressed by certain salient phenomena in the wild man's concept of disease etiology. He is also struck by the frequency with which first-hand observers, usually not medical men, adduce certain arguments by use of analogies which at first seem obvious, but which later to the professional man seem a little strained. The latter, I think, is apt finally to fall into the way of thinking of the phenomena from two points of view, one objective and the other subjective. Primitive demonology has been repeatedly associated with modern bacteriology by the ethnologist as a parallel etiological concept. He tends thus to bring into close apposition the first and the latest medical concepts of the causes of disease. It may not be uninteresting to review, in a very cursory manner, what we have learned of the universally accepted and long held theory of demonology as the cause of the ills of the flesh and of the spirit, from which man has suffered. Such theories were dominant until comparatively recent times—in fact during all but a few recent centuries of the many hundreds of years which have elapsed since we first catch a glimpse of the mentality of our ancestors. The traces of the idea are still so numerous and so apparent it is a work of supererogation to point them out in the current medical literature to discerning readers.

Before dwelling on demonology in the belief of primitive man as to disease we note the exceptions. We find primitive man thinking of disease as something which has gone wrong with his soul or his shadow or as due to the witchcraft of his fellows and finally to what we are pleased to call "rational" causes. We say these are the germs of "rational" medicine, but we must not lose sight of the fact that they were to him no more and no less rational than his other "reasons" for illness. They were undifferentiated. They were inextricably interwoven with his concepts of demons within and without him as the causes of disease and death. Over the whole was diffused a haze due not to deficient, but to unregulated mental processes—to mental processes which have less evolutionary past than our own. It was not because of lack of ability that he did not think clearly. Among them evidently there were men quite as capable of thinking clearly, but

doubtless they were as few as among us. It is said the vast majority of modern men only think they think and I suppose nothing more harsh can be said of the cerebral activity of primitive man. It is intimated that the cerebral functions of most of us now are mere imitations, reflex actions, mental contagion resulting in following the lead of some one who *can* think.[1] To think clearly is doubtless a rarity to-day, but we are justified in the belief that it was a much rarer phenomenon in the undisciplined mental activities of primitive man. This haziness of thought we must accept as undifferentiated, not as inferior mental activity. We can, thanks to our social and mental inheritance, differentiate demonology from other explanations of disease man made to himself in the infancy of the regulation of thought, but that differentiation is a modern not a prehistoric invention.

Inextricably bound up with the ills of the body among primitive men are the ills of the soul. Again it is all one and undifferentiated. His religion was real to him in the sense that it formed a part of the other realities of his environment. A very short reference to one or two aspects of this multiform pantheism will soon drift us into the demonology of disease. Thus his religious beliefs permeated his whole life on earth from the cradle to the grave and became a part of his very being, in a sense quite different from the spiritual inheritance he has left us. From the earliest times demonology was an essential ingredient of the oldest religious thought of which we have written records. A belief in every kind of demoniacal influence, which permeated not only the Babylonian and Assyrian people, whose heirs were the Jews, but the Hindus, was based on the supposed peopling of the air by spiritual beings—personifications or companions of storm and tempest. The very air itself had a spiritual meaning—expressed in etymology to-day. It is true some savages believe in beneficent powerful spirits or gods or even God, but for the most part they propitiate and concern themselves about the other kind, and pay little homage to those beings who wished them well, as indeed why should they? Their reasoning was much more consistent than ours. Why should a truly beneficent or a neutral God be propitiated? They needed all their slender stock of wealth and energy for the evil, aggressive kind. The idea of a beneficent god persecuting a poor human insect, busy with the mystery of evil, because he did not kneel to one superior to the demons that

[1] I do not think it necessary to pursue this train of thought further, familiar as it is to us in esoteric philosophy, but in self-defense I may add that I am conscious, if I did, of the necessity of entering into the interminable discussion as to how far, if at all, any thought is independent of "reflex action" and mental contagion and I suspect I should have to confess that essentially the "thought," of the follower is essentially the same as the thought of the leader. I am only here recalling certain conventional trends of modern thought, not asserting any justification for it in critical analysis.

dogged him did not readily enter their brains. We still are silent before the mystery of evil, but the heathen in his ignorance is not to be criticized for not being impressed with that kind of superiority or neutrality. He was very much more concerned, and rightly, with fending off devils of disease that lurked in trees and streams, praying to them as they still do in Shensi.[2]

There were those things in the wood and the water which had other functions, but the trees in Shensi are believed to be, as they are in other localities, "the dwelling places of spirits who possess the power of healing diseases and of bringing trouble to a happy termination," and when the sufferers who worship them recover, they furnish testimonials of their faith and gratitude by hanging red cloth on the boughs. Doubtless it is connected with the spirit worship of ancestors, which leads back to the necessity of diminishing their discontent. It is not always clear why certain trees are selected, nor why the trees sometimes cause misfortune and sometimes heal disease, but along the Han River

> The trees and rocks and the river itself are peopled by spirits, some of whom are good and some evil. The spirits are omnipresent and never sleep; they are all under the control of a mysterious being called the River Dragon.

There are few places left in the world where tree and water sprites linger to-day so undisturbed as they do in Shensi. In Australia they tell you:[3]

> Spirits were very plentiful before the arrival of the white man. A spring of fine water near Mount Kolor, called Lurtpii, was their favorite resort, and they were to be found there at all times by the doctor, who alone had the power to make them appear.

This needs no translation for us, familiar as we are with the harvest reaped still at "Springs" and "Spas" and "Bads" by modern wizards who people the evil tasting waters with healing powers.

From a recent remark of Dr. Mayer in regard to Papua[4] where the stone age lingers, we may see the reason why the primeval wizards more honestly entertained the belief in the magic of the waters.

> It is still a country of surprises, as when the petroleum fields, probably a thousand square miles in area, were discovered only about four years ago along the Vailala River, the natives having concealed their knowledge of the bubbling gas springs through fear of offending the evil spirits of the place.

It is quite evident here that the gas bubbles, inexplicable to the savage mind, were the "unknowable" element which deified the place and this may give us a clue to the gods and goddesses of springs at least. It is an excellent example of the readiness with which primitive

2 Nichols, F. H., "Through Hidden Shensi." New York, 1902.

3 Dawson, James, "Australian Aborigines." Melbourne, 1881.

4 Mayer, A. G., "Papua, Where the Stone-Age Lingers," SCIENTIFIC MONTHLY, Vol. 1, Nov., 1915, p. 105.

man endows the "unknowable" with divinity so natural to man even to-day.

Though this belief in tree and water spirits is absent from the theology of many native tribes, as specifically, though qualifiedly denied by Williamson,[5] for New Guinea, it is a very striking phenomenon with many, and in the classic times of Greek and later European literature it was embodied in many graceful and poetic legends. A traveler in the Andean region of the Argentine[6] relates that one of his men having a headache he called in a female native doctress who promptly ascribed his illness to the evil spirit in a spring near which he had camped the night before. One of these evil spirits had also taken possession of a spring near a house which, though the best in the town, was shunned by the natives for fear of being killed by the maleficent being. In Africa, on the West Coast[7] several varieties of trees are believed to be inhabited by indwelling spirits, which are not exactly gods, but answer more to the hama-dryads of ancient Greece, or to the elves of medieval Europe. With these people as with all primitive man witchcraft is

> the chief cause of sickness and death. They can not, they think, attribute these evils to the gods, unless they occur in some way special to a god; as, for instance, when a man is struck by lightning, in which case the event would be attributed to Shango—or contracts smallpox, when the disease would be attributed to Shanpanna; for they are very careful to keep on good terms with the gods, by scrupulously observing their religious duties. They consequently attribute sickness and death, other than death resulting from injury and violence, to persons who have for bad purposes enlisted the services of evil spirits, that is to say, to wizards and witches.

This is but a glimpse at the manifold and innumerable instances obtainable from ethnographic literature, of the way all external nature is permeated by anthropomorphic concepts of a motive power, which still troubles our own synods. As primitive man interpreted phenomena external to his body so he interpreted queer phenomena internal to it.

> The belief prevailing through the lower culture that the diseases which vex mankind are brought by individual spirits is one which has produced striking examples of mythic development. Thus in Burma the Karen lives in terror of the mad "la," the epileptic "la" and the rest of the seven evil demons who go about seeking his life.[8]

In old times it was the custom in the Shan States, as in Burma, to bury alive a man or woman under the palace or the gates of a new

[5] Williamson, R. W., "The Mafulu; Mountain People of British New Guinea." London, 1912.

[6] Boman, E., "Antiquités de la region andine de la République Argentine et du desert d'Atacama." Publication of the Mission Scientifique. C. de Crequi Montfort et Senechal de la Grange, tome II., pp. 579–589. Paris, 1908.

[7] Ellis, A. B., "The Yoruba-Speaking Peoples of the Slave Coast of West Africa." London, 1894.

[8] Tylor, E. B., "Primitive Culture." 4th ed. London, 1903. 2 vols.

city, so that the spirits of the dead in guarding the place from human enemies should also keep evil spirits that bring sickness at a distance.[9] Evil spirits as the cause of disease is a theory of its origin and nature which occurs

in various parts of the world, as for instance in Siberia among the Kalmucks, the Khirgiz, and Bashkirs; in many of the Indian tribes, as the Abors, Kocharis, Kols, etc.; in Ceylon; among the Karens; in the Andamans; in the Samoan, Harvey, and other Pacific Islands; in Madagascar; among the Caribs, etc. . . . So again in Guinea, the native doctors paint their patients different colors in honor of the spirit which is supposed to have caused the disease.[10]

According to the Bukaua, disease is a personified thing existing outside of man. It is rather remarkable that though the Bukaua is acquainted with the internal organs of man, he places them in no relationship to disease.[11]

In India

the people believe that in the blazing days of the Indian summer the Goddess Devi flies through the air and strikes any child which wears a red gown. The result is the first symptoms which less imaginative people call sunstroke.[12]

In Malaysia among the Mantra

all diseases are believed to be caused either by spirits or by the spells of men. . . . The Swelling Demon haunts the abodes of men, whom it afflicts with pains in the stomach and the head.

In the ground there lives a demon

who causes inflammation and swellings both in the hands and feet. . . . To enumerate the remainder of the demons would be merely to convert the name of every species of disease known to the Mantra into that of a demon or Hantu. If any new disease appeared, it would be ascribed to a demon bearing the same name.[13]

Im Thurn[14] very cautiously observes of some of the South American Indians.

By some observers among these and other tribes in a parallel stage of civilization, it has been supposed that all diseases are also personified and regarded as possessed of spirits, just as are material bodies, animate and inanimate. But it seems to me that, at least in Guiana, this is not quite the case. . . . It seems to me that these diseases are not distinct beings, but rather forms, visible or invisible, assumed by the spirits of kenaimas, who, as has been explained elsewhere, are capable of throwing their spirits into any body they please. When, therefore, a disease-spirit situated in the bodily form of a stick or stone is removed from the flesh of an invalid, this bodily form is only one

[9] Milne, Mrs. Leslie, "Shans at Home." London, 1910.

[10] Avebery, Lord, "The Origin of Civilization and the Primitive Condition of Man." London, 1889.

[11] Neuhauss, R., "Deutsch Neu-Guinea." Berlin, 1911. 3 vols.

[12] Crooke, W., "The Popular Religion and Folk-Lore of Northern India." Westminster, Eng., 1896. 2 vols.

[13] Skeat, W. W., and Blagden, C. O., "Pagan Races of the Malay Peninsula." London, 1906. 2 vols.

[14] Im Thurn, Sir E. F., "Among the Indians of Guiana." London, 1883.

of the infinitely variable number which the kenaima is able to assume; and when a forest path is blocked against the advance of a disease, it is blocked against the bodily form of a malicious kenaima. In other words, diseases are not, I think, distinctly personified.

This seems rather the refinement of criticism of a scientist than entirely to exclude the personification of disease. Elsewhere observers have not made any qualification as to the conceptions they found. In the Fiji Islands[15]

one of the fiends had a monster front tooth which curved over his head, and bat's wings with claws and was usually regarded as a harbinger of pestilence. . . . Among their gods was a god of leprosy.

How firmly this idea is rooted in the minds of some primitive men is to be noticed in an observation made by Boas[16] on the Chinock Indians. One would suppose a gun shot or arrow wound needed no divinity to account for the ensuing trouble, but,

as soon as it is discovered that a person is shot his friends endeavor to take out the disease. The conjurer clasps his hands so that the thumb of the right hand is held by the fingers of the left. He catches the disease in his hands. It tries to escape, and when the thumb of the right hand comes out of the clasped hands the disease has escaped. While he holds the disease in his hands, five people take hold of him, two at his legs, two at his arms, and one at his back. They lift him; then a kettle is placed near the fire and filled with water. They try to bring the conjurer to the water, but the spirit of the disease resists. When he escapes, the men fall down, because the resisting spirit suddenly gives way. Sometimes they succeed in carrying the conjurer to the water. Then the disease-spirit is put into the water. When it gets cold it loses its power. Then they look at it. Sometimes they see that the spirit is made of claws of a wolf or of a bird; and someimes of the bone of a dead person, which is carved in the form of a man.

It is no less real an impersonation on the West Coast of Africa:[17]

When an Abiku has entered a child he takes for his own use, and for the use of his companions, the greater part of the food that the child eats, who in consequence begins to pine away and to become emaciated. If an Abiku who had entered a child were not bound to supply the wants of other Abikus who had not succeeded in obtaining human tenements, no great harm would ensue, since the sustenance taken could be made sufficient both for the child and his tenant. It is the incessant demands that are made by the hungry Abikus outside, and which the indwelling Abiku has to satisfy, that destroy the child, for the whole of his food is insufficient for their requirements. When a child is peevish and fretful it is believed that the outside Abikus are hurting him in order to make the indwelling Abiku give them more to eat; for everything done to the child is felt by his Abiku. The indwelling Abiku is thus, to a great ex-

[15] Mayer, A. G., *Popular Science Monthly*, June, July, Sept., 1915, pp. 521, 31, 292.

[16] Boas, Franz, "The Doctrine of Souls and of Disease among the Chinock Indians," *Journal of American Folk-Lore*, Vol. 6, Jan.–March, 1893.

[17] Ellis, A. B., "The Yoruba-Speaking Peoples of the Slave Coast of West Africa." London, 1894.

tent, identified with the child himself, and it is possible that the whole superstition may be a corruption of the Gold Coast belief in the sisa. A mother who sees her child gradually wasting away without apparent cause, concludes that an Abiku has entered it, or, as the natives frequently express it, that she has given birth to an Abiku, and that it is being starved because the Abiku is stealing all its nourishment. To get rid of the indwelling Abiku, and its companions outside, the anxious mother offers a sacrifice of food; and while the Abikus are supposed to be devouring the spiritual part of the food, and to have their attention diverted, she attaches iron rings and small belts to the ankles of the child, and hangs iron chains round his neck. The jingling of the iron and the tinkling of the bells is supposed to keep the Abikus at a distance, hence the number of children that are to be seen with their feet weighed down with iron ornaments. Sometimes the child recovers its health, and it is then believed that this procedure has been effective, and that the Abikus have been driven away. If, however, no improvement takes place, or the child grows worse, the mother endeavors to drive out the Abiku by making small incisions in the body of the child, and putting therein green peppers or spices, believing that she will thereby cause pain to the Abiku and make him depart. The poor child screams with pain, but the mother hardens her heart in the belief that the Abiku is suffering equally.

There is always behind calamity some malignant power which selects the victim. The theory of disease among the American Indians of the Cherokee tribe Powell[18] sums up sententiously—"Animals, ghosts, witches." There are other causes in many tribes in almost every savage part of the world, but invariably the category includes these.

The Kafirs quite recognize that there are types of disease which are inherited and have not been caused by magic or by ancestral spirits.[19]

Of the etiology of West African diseases Miss Kingsley[20] says that some diseases are due to human agency:

The others arise from what is called witchcraft. You will often hear it said that the general idea among savage races is that death always arises from witchcraft; but I think, from what I have said regarding diseases arising from bush-souls' bad tempers, from contracting a *sisa*, from losing the shadow at high noon, and from, it may be, other causes I have not spoken of, that this generalization is for West Africa too sweeping. But undoubtedly sixty per cent. of the deaths are believed to arise from witchcraft. I would put the percentage higher, were it not for the terrible mortality from smallpox and the sleep disease down south in Loango and Kakongo, those diseases not being in any case that I have had personal acquaintance with imputed to witchcraft at all. Indeed I venture to think that any disease that takes an epidemic form is regarded as a scourge sent by some great outraged nature spirit, not a mere human dabbler in devils.

While essentially all disease, as we have seen, has its origin in the activities of ghost or spirit, or demon within the body devouring the patient's insides, they have not that concrete embodiment as a whole which is ascribed to the plainly contagious affections.

18 Powell, J. W., Seventh Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution, 1885–86. Washington, 1891.

19 Kidd, D., "The Essential Kafir." London, 1904.

20 Kingsley, M. H., "West African Studies." 2d ed. New York, 1901.

The Persian sees in bodily shape the apparition of Al, the scarlet fever: "She seems a blushing maid with locks of flame and cheeks all rosy red."[21] Amongst the spirits of disease, by the Mantra the smallpox demon is held in such dread that they have a repugnance even to mention his name.

Both the smallpox demon and the cholera demon, who is called Rak, are exorcised by means of a dance, during which certain magic formulæ are chanted by the magician.[22] From the same source we learn that

it will help us to an idea of the distinct personality which the disease demon has in the minds of the lower races, to notice the Orang Laut of this district placing thorns and brush in the paths leading to a part where smallpox had broken out, to keep the demons off; just as the Khonds of Orissa try with thorns and ditches, and stinking oil, poured on the ground, to barricade the paths to their hamlets against the goddess of smallpox, Jugah Penim. Among the Dyaks of Borneo, "to have been smitten by a spirit" is to be ill.[23]

In some parts of Africa a person dying of smallpox is not buried, "but the corpse is hung up to let the disease fly away with the wind, instead of keeping it about the place."[24] Thus we see disease devils without and within the body. I might go on to cite the instances of animals who have found their way into the wild man's insides, often causing mental troubles, or inanimate objects witched into him, as among the Australians or in South Africa, causing rheumatism and other troubles, but the list would be interminable. How these things work is probably not at all well figured out in the mind of primitive man. How a great demon with a curving tusk going up over his head would get inside of a little man it is hard to say. This is one of the things hid in the haze of primitive man's budding mentality.

Miss Kingsley in her humorous mimicry of West African English says:

In 1893 I came across another instance of the post-mortem practise. A woman had dropped down dead on a factory beach at Corisco Bay. The natives could not make it out at all. They were irritated about her conduct: "She no sick, she no complain, she no nothing, and then she go die one time." The post-mortem showed a burst aneurism. The native verdict was "She done witch herself," *i. e.*, she was witch-eaten by her own familiar.

In Guiana Kenaïmas,[25] in the form of worms, insects, or even inanimate objects, are supposed to enter the bodies of their enemies and there cause all headaches, toothaches, and other such bodily pains. In reference to the entrance into the body of worms and insects as the cause of disease, it is possible that the sight of dead bodies containing them may have given rise to the idea. Job (XIX. 26) refers to the worms

21 Tylor, E. B., "Primitive Culture." 4th ed. London, 1903. 2 vols.

22 Skeat, W. W., and Blagden, C. O., "Pagan Races of the Malay Peninsula." London, 1906. 2 vols.

23 Tylor, E. B., "Primitive Culture." 4th ed. London, 1904. 2 vols.

24 Werner, A., "The Natives of British Central Africa." London, 1906.

25 Im Thurn, Sir E. F., "Among the Indians of Guiana." London, 1883.

which "after my skin destroy this body." Williamson[26] says of the people of New Guinea:

A man with the toothache will say that "a spirit is eating my teeth." The people seem to have a knowledge of something inside the teeth, the nature of which I am not able to state definitely, but which apparently is, in fact, the nerve, and they recognize that it is in this "something" that the pain arises; but I could not ascertain the connection between this something and the spirit which is supposed to cause the trouble.

The way of thinking of the South Sea savage[27] is that in illness "the ghost is eating the patient," and the California Indians[28] believe the evil spirits "cause snakes and other reptiles to enter into their bodies and gnaw their vitals."

We can see how a thorn or a pebble in the cellular tissue causes inflammation, how the worms crawling from dead bodies may start the wild man's mind off on various theories of disease, but it is not always entirely clear to us, and their theories were doubtless not clear to primitive men themselves. They not infrequently sought to prove their validity. We have seen how they proved the woman with the heart aneurism had "done witched herself." In West Africa Miss Kingsley's attention was arrested by

seeing several unpleasant-looking objects stuck on poles. Investigation showed they were the lungs, livers, or spleens of human beings; and local information stated that they were the powers of witches—witches that had been killed, and on examination found to have inside them these things, dangerous to the state and society at large. Hence it was the custom to stick these things up on poles as warnings to the general public not to harbor in their individual interiors things to use against their fellow creatures.

They needed but to open the bodies of the victims to find the same, and thus the connection between the two was manifest. The widow Douglas had always told Huckleberry Finn the world was round like a ball, but he never took any stock in "a lot of them superstitions of hers." So he used to go up on a hill and prove to himself it was flat because he "reckoned the best way to get a sure thing on a fact is to go and examine for yourself and not take anybody's says so." This is the true scientific spirit and in many modern scientific minds like Huck's and the investigators in West Africa, untrained in logic, it leads to like results. This lack of reasoning and analysis, very apparent to us in the records of observers of primitive man and not by any means unnoticeable in the "deductions," "conclusions" and "remarks" at the end of many a

26 Williamson, R. W., "The Mafulu; Mountain People of British New Guinea." London, 1912.

27 Williamson, R. W., "The Ways of the South Sea Savage." Philadelphia, 1914.

28 Bancroft, H. H., "The Native Races of the Pacific States of North America." New York, 1875–76. 5 vols.

modern medical treatise, has in the course of ages perhaps been less conspicuous, but the way has always been set with pitfalls. After the rise of the cellular pathology we recognized that disease was dependent upon the destruction of cells. In West Africa the frequent localization of the devouring witch in the lungs is due, the Rev. Dr. Nassau[29] intimates, to the existence of the cavities of the third stage of consumption. He says in a footnote:

> Similarly I have known the fimbriated extremities of the fallopian tubes in a woman held up as proof of her having been a witch. The ciliary movements of fimbriæ were regarded as the efforts of her "familiar" at a process of eating. The decision was that she had been "eaten" to death by her own offended familiar.

This surprising note among other revelations demonstrates the value of early post-mortems. If you want to be sure of a thing, Huck Finn said, you want to go and see it.

Our cellular pathology seems now only a slight descent into the microscopic realm from the Zulu lesion, but at the time of its prevalence, we had become familiar with the action of chemicals and even of digestive juices on dead and living tissues. We knew of many chemical reactions in which the chief alteration of inert matter was one of oxidation, with the production of heat. Nothing was more natural than from this to arise an idea of inflammation in which the phlogiston theory was modified to express the destruction of tissue by a process of oxidation which accounted for the fever. Perhaps this is not wholly wrong as a conception of a part of the process of tissue destruction—not wholly wrong, but it was rapidly displaced by the advent of the living organisms of disease. We did not at first stop to inquire how they worked. We jumped at once from them to the lesion. Gradually bio-chemistry is coming to the fore and we are learning how the bacterial spirits of disease produce their evil effects, but with primitive man unacquainted with chemical action, when he got down to details, they were anthropomorphic—drawn from such experience as he had. The evil spirits bit and chewed and sucked the blood of the internal organs. How he thought the inert matter and the absent soul and taboos worked we do not know, but we have every reason to believe that, as a rule, he did not think at all. Even Lister felt it enough to demonstrate that germs present, disease occurs—absent, there is no disease. Lack of analysis in both cases is patent. We begin to know that disease germs present do not always mean disease present.

Demonology and modern medicine overlap one another throughout the whole historical period of 2,500 years, the thin edge of the latter reaching far back of Hippocrates and the tapering off of the former promising to reach far into the future beyond our day and generation.

[29] Nassau, R. H., "Fetichism in West Africa." New York, 1904.

One of the most learned of modern ethnologists curiously develops something of this train of thought—that interwoven with belief in the spirits of disease was an apperception of the truth which has swelled through the ages to the freshest of its manifestations in bacteriology. I quote from a recent article by Sir Harry Johnston,[30] who here seeks to illustrate the existence of that thin edge of the overlapping rationalism which lay alongside the large bulk of demonology—the orthodox faith of primitive man:

> Not only did the growing culture of the Neolithic and early Metal ages begin to perceive danger in the fly, in the locust, bug, tick, and mosquito, but an instinctive dread was felt of the invisible germ, the minute organisms which were not to be visually perceived by man till the seventeenth century of the Christian era and not to be in reality appreciated and understood till about fifteen years ago. This instinctive belief in the "germs" and the spread of germ-diseases was undoubtedly at the basis of the preposterous caste regulations developed by the Aryan invaders of a Negroid, Australoid India. They avoided the contact and even the proximity of the dark-skinned races over whom they had come to rule, because they associated such contact with the spread of disease. Though they assigned false reasons, they were right in the main—there is a good deal of common sense at the back of most religions—and it may only have been at first through the strictness of these precepts that the ancestors of the Brahman survived; though their descendants in modern India have resolutely fought the efforts to exterminate disease on the part of their recently arrived Nordic half-brothers, by refusing to credit the germ theories and to cooperate in modern measures of sanitation for the suppression of cholera, malarial fevers and plague.

At any rate, we may go far enough to assert that they were right to suppose that some external agent, demon or bacterium, introduced from without is the cause of most disease. Indeed, in pointing out the conception of a conflict of the evil spirits of disease with good spirits that defend the body within, we are perhaps within hailing distance of the time when Hippocrates defined disease as a conflict between opposing forces waged in the bodies of men and animals. It persists as the best definition of disease modern science can give, but the concept did not originate with Metchnikoff nor even with Hippocrates. For, of the people on the lower Niger, to whom neither Socratic nor Hippocratic wisdom seems to have penetrated, it is said that[31] "every medicine to be of any use must have within it a spiritual essence to defeat the operations of the aggressive invader. . . ." And they use certain, to us, senseless precautions

> in the firm belief that the spirit of the medicine will keep the spirit of the disease from attacking and infecting the wearers of the fetish. When, however, it fails to do this, the latter spirit has simply vanquished the former; the spirit of the disease has been too strong for the spirit of the doctor's medicine.

[30] Johnston, Sir Harry, "The Nineteenth Century and After." July, 1915, p. 151.

[31] Leonard, A. G., "The Lower Niger and its Tribes." London, 1906.

With anthropomorphic conceptions of the unknown, perfectly justifiable from their point of view, their actions, to us absurd, are entirely rational. Not only were various objects living and dead, as they are with us, made to serve as refuges for these disease devils, but to make the analogy closer we have seen Johnston trying to connect their demons up with our little devils, which at last we have managed to see. Innumerable forms and variations are to be noted in their medical practises, but they are all based on the idea that the cause of disease is some specific living object. We have identified it as a germ, but the germ of the idea existed many thousands of years before the discoveries of Pasteur and his predecessors. This similitude of conception has been dwelt on by others, especially by Miss Kingsley, who remarks of the devil sent in to drive away the disease devil, "a leucocytes versus pathogenic bacteria sort of influence, I suppose," by Johnston, just alluded to, and by another observer of the African mentality. Dowd[32] says:

> It is pretty evident to an unbiased mind that our microbe or bacteriological theory of disease is merely a thinly disguised imitation of the African spirit theory.

It is not only the ethnologist, but the archeologist whose thought is pervaded with this analogy between the primitive man's little demons of disease and modern man's devilish little disease germs. It is Jastrow,[33] the Assyriologist, who is struck by it. In old Babylon

> the evil spirits supposed to cause sickness and other ills were of various kinds, and each class appears to have had its special function. Some clearly represented the shades of the departed, who return to earth to plague the living; others are personifications of certain diseases. The existence of special demons for consumption (or wasting disease), fever, ague, and headache forms a curious parallel to specialization in the practise of modern medicine. There was even a "gynecological" demon, known as Labartu, whose special function it was to attack women in childbirth, and steal the offspring. . . . In short, like the modern "germs" of which they are the remote prototypes, they are universal and everywhere. They move preferably in groups of seven.

Elsewhere[34] he points out that in ancient Assyro-Babylonia

> a cure, therefore, involved driving the demon out of the body, either forcing him out or coaxing him out. Incantations as a means of bringing this about are therefore to be viewed as the antitoxins of primitive medicine, acting primarily on the demons, and merely as a resultant incident bringing about the cure of the patient.

32 Dowd, J., "The Negro Races." New York, 1907–14. 2 vols.

33 Jastrow, M., "Aspects of Religious Belief and Practise in Babylonia and Assyria." New York, 1911.

34 Jastrow, M., *Proc. of the Royal Soc. of Medicine*, Vol. 7, No. 5, Hist. Section, 1914, pp. 109–176.

Incantations, however, have not as much affiliation with modern bacterial therapy as another prehistoric performance. In Preuss's book on the medicine of the Talmud[35] he refers to the fact that Varro and Columella in the first century after Christ ascribed the diseases of Rome to little animals, which live in the swamps and are breathed in by men. These little animalcules he insists are no nearer parallels to the spirits referred to in the book of Tobit as *mazziqin* than are the microorganisms of the modern bacterial theory in spite of the fact that they closely resemble the concepts, if they are not identical with the Babylonian demons, that peopled the air of Mesopotamia and entered the bodies of men to their destruction. He admits that the Egypto-Assyrian prototype of the Jewish and Christian censers, smoking with resinous drugs which developed the antiseptic vapors of ethereal oils, forms some sort of a parallel with the now discarded weapons of the fumigators of our boards of health in their early bacterial days. His scorn of this sort of thing doubtless was expressed after the wane of this enthusiasm of early bacteriological orthodoxy. Nevertheless, even though no more than a coincidence, other things taken into consideration, it is rather remarkable that antiseptic ethereal oils were let loose in fumigation to exorcise the little demons of disease in old Judea some 3,000 years ago and let loose again some 30 years ago to exorcise the little red and blue devils we saw under our microscopic objectives. The efficacy of the fumigating performance, so far as the disease is concerned, doubtless was the same, but there is no occasion for scoffing at the performance at either date, but rather for reflection on the transitoriness of theory and the evanescence of facts. In disgust he says:

> Statt die heiligen Schriften zu verherrlichen, wie sie meinen, machen sie sie und sich lächerlich.

There is a good deal of the hiss about this, but it is indeed not Holy Writ that is made ridiculous alone. All but recent sanitary science comes in for its share.

As I remarked at the opening of this short review of an interesting passage in the history of primitive medicine, there is an objective and a subjective aspect of it. The phenomena as they presented themselves to primitive man's consciousness were practically the same in his time as in ours. "Here is a man well and like the rest of us yesterday. To-day he is languid and feverish and weak. Something ails him, something has got into him," to use a modern vulgar colloquialism which expresses it all, both in the ancient and the modern concept. "I have made acquaintance with a number of active two-legged things much like myself and I know other four-legged things less like myself and

[35] Preuss, J., "Biblisch-talmudische Medizin." Berlin, 1911.

some crawling things not at all like me. That's about all I know that harms a man." "Yes," says a skeptic, "but these we can see or feel or smell." "Whatever it is that has got into our fellow man doubtless is like some of the other things we know, only it can't be seen, nor felt nor smelt," says the ancient constructive scientist; "Must be something too small to see with the naked eye," says the modern theorist, who knows there are such things and how difficult it is to see them even through a double convex glass or even through a combination of them. Thus far then the prehistoric and the modern scientist follow the same trend of thought. They reason from a knowledge of things they know to things they do not know. Early man did not succeed in seeing his demon and he made mistakes about his attributes. Modern man finally saw the demon, but it is very evident that the early bacteriologists, who first saw him in connection with disease, also made mistakes as to his attributes, though they seem to have classified him a little differently. Reasoning from analogy is often man's only resource, but it is a fallible one and it is curious to see how it has helped him and how it has deceived him, both in his primitive and in his more sophisticated state. It is, however, all very logical. Given the same phenomena of nature and the same receptacle of the impressions they make—the same brain—we find the latter now making the same response to direct stimuli as it did at the dawn of the reasoning processes, differing only in the influence of an accumulated experience and in the inheritance of past achievements.

On the subjective side of this matter as I write I am reminded by a recent New England author of Puritan descent, somewhat given to forcing analogies, that

> what Augustine and Calvin saw, in the human affairs whence each alike inferred the systems of Heaven and Hell, was really what the modern evolutionists perceive in every aspect of Nature. Total depravity is only a theological name for that phase of life which in less imaginative times we name the struggle for existence; and likewise election is only a theological name for what our newer fashion calls the survival of the fittest. Old-world theology and modern science alike strive to explain facts which have been and shall be so long as humanity casts its shadow in the sunshine.

One hesitates whether to accept the view that the human mind runs easily only along certain grooves, or whether the impulses which set it in motion are really so identical in their tendencies and so accurate in their aims that ends are arrived at which if not identical are, it must be confessed, curiously analogous. On the whole our modern philosophy teaches us that the impulses may be marked, but more or less indeterminate and aimless. The mental momentum they set up glides into

grooves or paths which previously expended energies have ploughed and blazed through the intricacies of past cerebral activities. It is in this way we may account for the complacency with which the fit who have survived contemplate themselves as the elect and in the analysis demonolatry can claim what it really had in mind all the time was bacteriology.

THE REAL IN SCIENCE

By Professor JAMES BYRNIE SHAW
UNIVERSITY OF ILLINOIS

WHEN one looks over the world of natural phenomena and begins to study it in all its complexity, his usual motive is that of organizing it in some way, so that he may lose the feeling of bewilderment and the sense of being overwhelmed by the multitudinous sea, and the scornful mountains, may in some way feel that he is master of the serene clouds and the flash of lightning. He feels within himself that he is superior to these exterior things in many ways, and that if he can understand them and their ways of behaving he can control them. He is also dominated by a feeling for beauty, and the disorder he finds in his impressions of the world shocks this esthetic sense, so that he undertakes to examine the world closely to see if perchance there be not some hidden beauty in it after all. In the pursuit of these aims he describes and catalogues facts, orders them by relations that his mind finds, deduces statements that comprise many facts in small compass, generalizes these into laws, and the laws into systems of science. He endeavors to reduce the number of variables in terms of which he desires to express himself to the fewest he can. He thus comes to feel in the end that when he has succeeded in stating an unlimited number of facts in a few laws containing a few terms, and particularly when by these he can make predictions that are closely fulfilled, he has discovered the reality of nature. He thinks he has analyzed phenomena into their constituent elements, and that these elements are permanent and unchanging in their real nature, and he considers that therefore they may be correctly called realities. We may, therefore, as philosophers ask the scientist to justify his claim that he has found reality. Many scientists of late have considered the challenge. Instances are Poincaré and Enriques, who have treated the problem in masterly fashion. It is indeed the scientist himself and not the philosopher who can properly consider the problem, for science must be allowed to speak from its own standpoint, and value its results by its own standard. We may, however, all of us, pass judgment on the content science puts into the word real, and upon the precision of its statements as to what it desires to prove regarding the real.

We need too to take into account the very closely allied field of mathematics, for we must not confuse mathematics with science. They differ radically in content, method, foundations, objects, and validity

in experience. The more fundamental would seem to be mathematics, for we can scarcely eliminate it from any kind of thinking. In science particularly the dependence is great. We find, for instance, that the planets describe twisted curves through the centuries; lines of force stream like gossamer threads from electron to electron; the quivering ribbons of the aurora illuminate the pages of electrodynamics; particles of air leave streamlines with intricate turns and interwoven loops, with vortices whirling in the turbulent current; the molecule zigzags its dizzy path through the colloidal solution; wave-fronts that bend and warp fly through space with every snap of the wireless; quanta of energy, electrons, magnetons, as well as gravitational particles, if there be such, make space granular with singular points; the facets of every crystal flash with groups, electric and magnetic fields move like expanding clouds, with congruences of lines darting out like lightning flashes; the trihedral of polarized light spins like a firework; the spectrum hues are close to the roots of an infinite equation; the moving system finds a minimum variation; the mended rubber tube is full of integro-differential equations; the laws of statistics blush in the petals of every daisy; and nature in her wildest vagaries preserves the decorum of the laws of probabilities. One may study mathematics with little study of science, but one can not go far in science without the constant study of mathematics. Mathematics conditions the scientist with inflexible rules, which he must not transgress, and, at the same time, it gives him freedom from postulates that he himself at first considers binding, together with methods that are independent of the visualizing power or other concrete modes of thinking. It thus becomes evident that the answer to many an inquiry of the philosopher in the field of science may be discovered by asking the same question in the field of mathematics. The wistful soul of man has often turned to both, indeed, asking for real gems and a draught of real inspiration, after it has been deceived by the magician's fool's gold and glittering mica which it took for real wealth, or has panted long and far after the philosopher's mirage with cool waves and shady palms that only tantalized its thirst.

The real in knowledge—which does not vanish as the dew in the morning sun, or the mist in a frosty night; the real of knowledge which does not beckon like the will-o'-the-wisp to swamps and mires; the real of knowledge which does not in the eating turn to ashes and bitterness—the real of knowledge, which is as fixed as the constellations that stud the nightly sky; the real of knowledge, which is as solid as the ragged peak, defying storm, wind, lightning, and seasons; the real of knowledge which illumines the path with a flood of white light—where is it to be found? Is it only a vain hope? We turn to mathematics and can answer confidently, no. For through the turmoil and vicissitudes of

eight millenniums, through the whole enormous stretch of human history—we find arithmetic, the guide of the astrologer predicting the fortunes of the royal infant, and the companion counting the pennies of the flower girl in the streets of Babylon; noting the tale of conquered land under Rome, and the vanishing ranks of the crusaders; building the towers of modern Babel, and numbering the loaves of bread the poor shall eat to-morrow. Here is a kind of reality, at least. Again for three millenniums, we see geometry settling the property-rights of the Nilean owner, determining the blocks of the pyramids, constructing the Eiffel tower and the Quebec bridge. Here-in is surely the real. For how can that which is not real persist for thousands of years? During the last century and a half, mathematics has determined the swing of the stars in their courses, it has built telephones and telegraphs, saved the victims with wireless, and is present in every sphere of human life of to-day. There must be reality in its world, for how else could these facts be?

It is a hoary question of the race. Perhaps not arising in ancient Asia, for there the search was not for reality, but for a mystical Essence older than life and nature; but in Europe the problem was discussed many centuries ago.

There was a brilliant genius, who watched the stately march of the stars from the mountain tops of Samos, or drew diagrams on the wave-washed sands of the Icarian beach, or laid out magic squares, or charmed his select group of initiates with his lyre and the beautiful relations he had found to exist between tones and numbers. In the cube he found a symmetry of form, and in its 6 faces, 8 vertices, and 12 edges, numbers that gave the fundamental tone, the quarter, and the octave, harmony in form, in number and in music combined. How far he penetrated similar symmetries in the world about him it is hard to say, but certain it is that he saw the universal presence of mathematics, and the intuition flashed through his mind into the world that mathematics could account for the whole universe. Mountains and sea, the soul of man, and the justice in society, could be explained in this way. Triangles, squares, pentagons, spheres, cubes and other figures were certainly incarnations of number, and so were tones of the lyre, why not all the phenomena of nature? The heavens must rotate in perfect circles, and there must be a music of the spheres so subtle in its numerical structure that only the most profound could hear it. The earth must be a sphere, for was not the sphere perfect in all its parts? If he had sensed the modern group as it is present in crystals dug from the mountain cavern, he would have been even more firmly convinced that number is at the heart of every structure. But he did have the vision of mathematical concept matching natural object, mathematical

structure matching the intricacy of natural phenomena, yet all with certainty, elegance, proportion and harmony. He saw mathematics building a tremendous symphony out of the orchestral music of nature. Across twenty-five centuries we see Pythagoras's majestic figure and appreciate his far-sweeping vision.

Half a century later Heracleitos mused by his fire on the bank of an Ephesian brook. The fuel disappeared as the flames danced and the smoke drifted away. He watched the water hurry over the rocks in a tumble of white foam, sweep past and vanish down the slope. Mists rose from the Ægean Sea and became drifting clouds; they broke and descended in rain which disappeared into the ground. He too had the penetrating vision of the seer as he watched the glow of the coals, and with much irony on the folly of the half-informed, the reveler, and the fickle-minded, he drew his vision in a few immortal strokes:

> Fire lives by the death of earth, and air by the death of fire; water lives by the death of air, and earth by the death of water. This order, which is the same in all things, no one of the gods or man has made, but it was ever, is now, and ever shall be an everlasting fire, fixed measures of it kindling and fixed measures of it going out.
>
> You can not step twice into the same stream, for ever fresh waters flow in upon you.
>
> The quick and the dead, the waking and the sleeping, the young and the old, are the same; for the former are changed into the latter and the latter into the former.

Is this only vague Hellenic metaphysics? Salt disappears in water and we have neither salt nor water; the molecule breaks up into atoms, the atom into electrons and nucleus, which are all in incessant motion, and occasionally explode so that new atoms are formed. The nucleus shrinks and expands and may itself be a complex system. Energy flows out into space and is dissipated, whither who knows? Nor whether it may not be regathered into blazing suns! The Brownian flashes, the pulsating cell, the evanescent process of mind, all prove that the universe is incessant change, and that it is extremely unlikely that any one of its configurations is ever repeated. The song vanishes with the singing, the landscape with the seeing, the dream with the dreaming.

> Onward and on, the eternal Pan,
> Who layeth the world's incessant plan,
> Halteth never in one shape,
> But forever doth escape,
> Like wave or flame, into new forms,
> Of gem, and air, of plants and worms.

Did not Heracleitos have a vision of the evolving universe, wherein all is in motion and motion is in all, whether particle of ether or propagation of an insubstantial state, or the intermingling fields of electric and magnetic action, or the creative evolution of electron, matter, and life?

Yet another half century and we stand with Parmenides on the shores of the blue Mediterranean, the same day after day and night after night despite dancing waves and casual sail; admiring the golden sunset that came every evening, the same sun in spite of storm and wind; the stars in rigid constellations traversed the dark blue sky, preserving their paths despite the few wanderers; the Italian mountains in the distance always the same despite the shifting lavender, amethyst and purple on their slopes. Austere and dignified one must be who sees things like these, and what he thought he put into a poem:

The world is, and it is impossible for anything not to be. For one can not know what is not—that is impossible—nor utter it, for it is the same thing that can be thought and that can be. It needs must be that what can be thought and spoken of is; for it is possible for it to be, and it is not possible for what is nothing to be. What is, is uncreated and indestructible, alone, complete, immovable, and without end. Nor was it ever, nor *will it be;* for now *it is,* all at once, a continuous one. How can what *is* be going to be in the future? or how could it come into being? If it come into being it is not; nor is it going to be in the future. Thus is becoming extinguished and passing away not to be heard of. Moreover it is immovable in the bonds of mighty chains, without beginning and without end; since coming into being and passing away have been driven afar, and true belief has cast them away. And there is not and never shall be any time other than that which is present. Wherefore all these things are but the names which mortals have given, believing them to be true—coming into being and passing away, being and not being, change of place and alteration of bright color.

But this too is modern science, for is not energy always energy, helium always helium, electrons always electrons, momentum always momentum, ether always ether? From acorns we always have oaks, and from thorns never grapes nor figs from thistles. The wave runs over the field of bending grain, but the motion is illusion, for the grain is always there; glacier and sea and cloud seem diverse, but are in reality only forms of the same water; the moving picture is a clever trick, which shows that all motion may be mere illusion; actual diversity of substance no longer exists in chemistry, the only diversity being one of combination, just as groups of men collect, and separate to form new groups. We can very well agree with the vision of Parmenides as he looked across the sea from his lofty summit, for the aim of modern science is to discover if it can the ultimate realities in terms of which all the forms of nature may be stated. For this reason it invented an ether, in which indestructible, uncreatable vortices constituted matter, stresses constituted electricity, while all the phenomena of electromagnetism were due merely to ether flow. It is for this reason that science seeks to reduce all the phenomena of life to the nicely balanced play of forces that are already in the system and to account for behavior in the same terms. This is the monistic dynamical view of the universe. We need not pause to trace its forms throughout the twenty-

four centuries since Parmenides, nor the forms of the views of Heracleitos or Pythagoras, for they have appeared many times as new philosophies, more acutely stated but not more far-reaching.

Daring thinkers they were, who had no degrees, no elaborate equipment, no research programs, no reference libraries! They faced the sphinx and from her mysterious lips heard answers which were contradictory and yet all correct. Who denies to-day that the world has a mathematical structure, from the electrons in their orbits and the quanta flung off from the radiating vacuum? Who denies the universal validity of the laws of conservation of energy, of momentum, or varying action? Who does not see the instantaneous evanescence of all the phenomena of experience as the mighty pendulum of eternity ticks off the seconds of the universe? Whence? Whither? What? Is the world but the projection of a mighty lantern on the screen of the senses? Are we tricked into imagining there is something real and permanent in the universe? Is the mathematical structure after all the only permanent part of the universe, and the other seeming realities merely aboriginal and naïve delusions, like the ghosts, goblins, elves and phantasms of the past? When we read modern works on electrodynamics, we seem indeed very close to this view, for the geometry of a non-Euclidean four-dimensional space seems amply able to state every known phenomenon of physics and chemistry. Or does indeed the mathematician dream, and in his dream see a fairyland of frost which is too beautiful and too fragile to exist in the sunlight of prosaic every-day life? Many things once thought real have vanished. The ether was so real that its density was about that of air on the summit of a mountain two hundred miles high, its rigidity about a billion times that of steel, yet to-day what is the ether? The mass of a body was once supposed to persist through the most fiery tests, yet to-day it varies with every change in velocity, and may be merely a number which is zero when there is no velocity. Space at least was supposed to be exempt from the vicissitudes of public opinion, and the intense cold and emptiness of interstellar space has chilled many an emotional mind. Yet to-day we have our choice of three incompatible spaces for the universe to exist in, with absolutely no way of ever deciding in which we really live. Time was supposed to be almost the last foundation of the world, even under the series of caryatides that supported the universe, but time is for science to-day a local phenomenon, so that we do not know what the same time in Europe and America can mean, and events may happen which are neither simultaneous nor yet one before the other. The dimensions of space seem a fundamental reality, yet we do not know whether we live in four dimensions or more, or simply three. Inspect the list of terms from modern science closely: ether, electron,

energy, mass, space, time, dimensionality, and we might add many more. Do they represent realities or are they merely fancies of our too easily illusioned minds? Where is the criterion we can apply with some assurance of certainty?

Is it in the senses through which all observations are made? Who then has seen the ether, or space, or a wireless wave? Who has heard energy or put entropy into a vial to be smelled or tasted? What sense feels the X-ray, or what finger can wind up the magnetic line of force? Who ever moved a Faraday tube with its ends fixed—that reality of which Thomson builds all electrodynamics? Who can detect gravity by his senses as it swings the stars along their ponderous curves? Even if recording instruments of every type, cameras, chronographs, or automatic apparatus of every description, had for thousands of years kept as faithful an account as the recording angel, nowhere should we find in these records energy, space, waves, entropy, temperature, fields of force, life or mind. None of these is to be grasped by the senses. Even number—that is not given by the senses either. I sit by the table and watch the flashing scales of the goldfish in its bowl. I see one fish through the side of the bowl, another through the top of the water. My finger reports one fish, my eye two. Feature to feature, shining scale to scale, motion to motion, the two fish are exactly alike. Does my eye report reality if there be one fish, or my finger if there be two? If one, which one is the real one, which the illusion? Even a camera would show two fish, yet a balance would show but one. And the whole of human experience reveals the same doubtful character of the testimony given by the senses. Unless we were to arbitrarily endow ourselves with an intuitive power of seeing with an internal eye realities given by the senses, we must admit that if only what the senses report is to be accepted as fact then we are poor indeed in realities. Heracleitos must have been right, for the world of the senses is ever shifting, ever new, always a swiftly flying present, and full of contradictions.

Is reality then to be found only in our inferences and deductions from the phenomena of experience? From the observations of his predecessors Ptolemy inferred a structure of the universe which is complete, accurate, and can never be contradicted by nature even if nature should turn out to be full of discontinuities. For his system was built on Fourier series, though he was unaware of the fact, and even discontinuities do not bother Fourier series. Yet we accept as the reality in the structure of the universe the Copernican system. Can then inference give us unreality as reality? Maxwell proved that electricity was an ether stress and discovered wireless waves merely by inference. Yet there is no ether and a wireless wave is a wave with nothing to wave. Indeed it makes no difference whether we suppose there is an ether or

that there is not an ether. Where then is reality in inference? Is the inferred rotation of the earth a reality or merely a convenient fiction? When we see the Brownian fireflies in the ultramicroscope, are the flashes reflected from the surface of a molecule, or from the modern complicated system called an atom. The latter statement is much like saying the solar system reflects light. Is color real, or is the reality only a number attached to a periodic phenomenon which has lost even the tenuous phantasm called an ether as its support? Is a symphony only imagination, while the reality is a series of complicated pulses propagated through the air? Is a cube real? For thousands of years men have studied the cube and always reported the same facts and theorems about it. Inferences may not give us reality any more than sense-perceptions. We find the same contradictions everywhere and not merely confined to physics or chemistry, biology or psychology. For long ago the Sphinx crouched no longer in stone:

> She melted into purple cloud,
>   She silvered in the moon;
> She spired into a yellow flame;
>   She flowered in blossoms red;
> She flowed into a foaming wave;
>   She stood Monadnoc's head.
>
> Thoro a thousand voices
>   Spoke the universal dame:
> "Who telleth one of my meanings,
>   Is master of all I am."

Perhaps here is the way out of our difficulties. If we can unriddle the problem of reality in one instance we may hope to do so in others. Therefore we turn to the universe of the mathematician, for here indeed the problem has been solved, and what reality is, what fiction is, can be ascertained.

II

Mathematics is a vast world of objects and their transformations with both static and dynamic features, intricate and tangled, yet systematic and ordered to a degree far greater than any other known world at present. It is a world created by the mind of man, partly in order to enable him to handle the numerous phenomena he studies, but mostly for the elegant beauty of the objects. The mathematician is an artist who works in a more subtle material than paint or stone, or even tone and words. In recent years he has busied himself with a consideration of just what kind of world he dealt with, and he finds he does not discuss the natural world, though he may receive suggestions from it, but that he creates a world and that the objects of this world grow more numerous day by day, more elaborate, more interconnected, and

yet as time passes this world is permanent and becomes a heritage of the race. The mathematician has concluded that man has always exercised this creative function of his intelligence, indeed perhaps that is the chief function of intelligence. He is convinced that the unknown is merely the uncreated, that uncomprehended complexity is merely chaos and not complexity at all. We can not stop to consider this conclusion of a large number of the masters in this branch of human knowledge, but we may notice just a few of the lines along which this creative evolution has proceeded.

Before the pyramids reared their vertices toward the Egyptian sky, before the valley of the Euphrates was cultivated for its grain, long, long before the first record of history there were men who fought the wild beast and took from him his skin; who fished the lakes and carried home their catch; men who met each other and compared the objects they had gathered. Desire for the other man's booty arose, and when they did not fight for the possession of the treasures, they bartered for them. A skin for a carcass, a small skin for a fish, a handful of fish for glittering stones or perhaps for curiously marked shells; at first a direct handing over of object for object, but later a tally of the objects, a conception of the fact that the parts of the body could represent the collection to be bartered—such was the beginning of the haughty aristocrat of mathematics, the theory of numbers. The Zuñi tallies with his fingers successively and says: the beginning, taken with the first, the middle of the list, all but one, the lot, one with the lot, another with one and the lot; the Bugalai says, little finger on the left, second finger, middle finger, index, thumb, wrist, elbow, shoulder, left breast, right breast; the Australian knows but the single thing and the couple; the Polynesian counts by pairs, by quadruples, and by tens, hundreds, and thousands, for he laid out small objects by pairs, one in each hand, and breadfruit he ties in pona of four each, so that takau means ten, twenty, and even forty; the Maya counted by scores and scores of scores. In this simple manner was suggested to the mind first the correspondence of the tally, then the image of the tally, and finally one brilliant day there flashed into existence the concept which dispensed with the tally and the image. At first the primitive bookkeeper kept his accounts by tallies of some sort, but in the course of time as transactions were more complicated, he was forced to invent a two, a four, a five, a ten, a score, a hundred, a four hundred, even a million, which did not consist of the tallies nor of the parts of the body that were used to tally, but of real abstract numbers. For these he invented arbitrary signs, which no doubt were crude imitations of the objects he had used for tallies. When we reach civilization's story we find the Chaldean astrologer counting by sixties, and writing his numbers by the principle

of position of the symbols, so that he has even sexagesimal fractions, a very elaborate system indeed. Ultimately man was compelled to study this world of number that he had thus created, not as a sort of distillation of many trades or barters, nor as a shadowy composite photograph of the various pairs, quadruples, tens of millions, that he had seen or handled, but as a sharp and definite concept of an object which could not be perceptually visible, but which nevertheless existed in the imagination as a real object. The mathematical imagination, in other words, had begun to create the series of objects which through long eras has become a tremendous world almost commensurate with the world of phenomena. We may easily imagine the primitive bookkeeper keeping tallies on a stick, just as many of the ignorant of our own time do, with big notches for the tens, and very large ones for the hundreds. We may imagine their admiration for the genius who first invented symbols for the tallies and kept the count in his head, taking the objects to be bartered by fives or even tens instead of by ones. We may speculate about the prehistoric period during which these symbols grew in different places into systems of notation, in Chaldean cities becoming the very intricate sexagesimal scale which was useful to the wealthy Babylonian as he counted his millions, and to the astrologer who scanned the jeweled sky for mystic information. The invention of such a system of objects with their multiplication table, addition table, notation of a very effective type, the ability to calculate by means of this invention, and thus to dispense with the handling of large groups of objects, was surely a brilliant inflorescence of the human mind. It eventually dawned upon the mind that in these numbers alone there was a world very well worth the study, and while Cyrus was seizing the treasures of Crœsus, while the Cumean sibyl was burning her prophecies by threes in front of Tarquin, Pythagoras was instructing his initiates in the mysteries of even and odd, and even-odd numbers, perfect numbers, the harmonic mean, squares and rectangular numbers, squares whose sum by twos is a square, and other properties of these purely mathematical objects. They hoped indeed to explain the whole universe by means of these properties alone, just as many another philosopher since has hoped to resolve the universe by means of other mathematical creations.

An unlucky day for them, however, and a lucky day for us came when it was discovered that the diagonal of a square could not be represented by an integer, no matter what number was taken for the side. Here was a downright failure to explain even mathematical objects by numbers, that is the natural numbers, and all hope of extending them to the universe vanished. It was a lucky day, however, because it suggested to the mind that the list of mathematical objects

be enlarged by the creation of the irrational numbers. These include not only the radicals, like $\sqrt{2}$, $\sqrt{3}$, $\sqrt[3]{2}$, etc., but infinitely many more, such as π, e. Up to the present time no need has been felt to create a further addition to the list. Should the time come, however, as there are some indications that such a time is almost at hand, when it will be necessary, in order to deal with phenomena, to have a set of numbers of higher dispersion, let us say, they will be easy to create and will be readily studied. The modern theory of pointsets and of ensembles in general will take care of this. With the creation of the irrational disappeared counting on an abacus, or tallies of any kind. Concrete objects are useless in handling these numbers, and the mathematician must use his inner eye.

For more than two millenniums the world of number had no evolution. Kingdoms rose and fell, wealth was gathered and vanished to the corners of the earth. Learning of one kind or another made some advance, but the mind was content with its numerical system as it was. Then while Thomas à Becket was quarreling with Henry II., while the crusaders fought about Jerusalem, on the banks of a lotus pond in India Bhaskara watched the swaying lilystalks, and the golden bees that settled in the flowers, and wrote a treatise on "The Beautiful Science, *Lilavati*." Perhaps he was not much more than a compiler, but at any rate we find in his book a new and startling kind of number: numbers that were at first called less than nothing, negative numbers, numbers of which he says the people do not approve. These numbers arose just as did the natural numbers, in the attempt of the human mind to manage the world of its experience. In trying to solve quadratic equations the mind had found it necessary to invent a new kind of number, for sometimes the equation could not be solved without using what we now call negative numbers. Nowhere in all the barters and the mercantile transactions of the past had there been anywhere found a negative number, any more than there is an irrational number to be found in nature. These had arisen as necessary to satisfy the symmetry and harmony of the mind's own world of number, and for purely conceptual reasons. True, in the course of time it was found that the bookkeeper might use these numbers in his credit accounts, if he so chose, but for many centuries they were considered as purely fictitious and of doubtful utility.

The Americas were discovered, and while DeSoto was exploring the Mexican deserts another unscrupulous adventurer was exploring the deserts of algebra, finding and passing by as unprofitable one of the strangest flowers of the field of thought. The square root of minus one, a more daring conception than had yet burst into bloom in all the history of human knowledge, after centuries of slow evolution of the flora

of arithmetic, sent up a solitary stalk and spread its petals to the brilliant sun of the renaissance of thought. Shunned at first as if it were the work of an Aztec sorcerer, for three centuries it slowly spread, until in the modern theory of functions of a complex variable it began to be cultivated for its far-reaching uses. A creation directly from the mind of the race, never discovered in trade, nor in any application, looked upon as an impossibility for centuries, still called imaginary, it has become indispensable even to the practical man. For listen to the wireless call for immediate help, and know that therein is the essence distilled from this once unknown, uncreated flower. The years passed to the number of more than two hundred and fifty, before even a geometrical application was found for this imaginary number and its kind. Certainly we have here at last an indubitable creation of the mind of the mathematician. And, almost 300 years after its appearance, the brilliant Hamilton announced a new variety of number whose inflorescence is clustered in tetrads of imaginaries, and whose beautiful symmetries are the delight of all privileged to perceive them. Since his time species of number have appeared bestarred with imaginaries of very bewildering types, hypernumbers of almost infinite variety, and the mathematician is aware fully at last that he can at will, like Prospero, summon these magic flowers from the chaos of the uncreated, but unlike Prospero's cloud-capped towers they do not vanish with a wave of the wand, rather they spread luxuriantly and bloom superbly, and from them we extract elixirs and perfumes.

We turn back the record again to the age of the Seven Wise Men of Greece, to the beginning of the geometry that was destined to be one of the glories of early Hellenic thought. Whatever it may have been under the great thinkers of Chaldea and of Egypt, it is here that we first find it spreading wide its theorems. Indeed so marvelous was the development of the geometry of Euclid and his successors, that for two thousand years it seemed as if here indeed mathematics had met reality and conquered it. The irresistible power of logic seemed to open all the secrets of space, and it was as rank heresy to question the *a priori* character of geometry as that of theology. Galileo horrified the authorities with his assertion that the earth moved, and a century later a timid Roman priest undertook to show the heresy in supposing that every line had several parallels through a single point. He failed mathematically, his name is almost forgotten, but unwittingly he too had seen the first single flower of another new world. Many decades later Lobachevsky, bolder even than the great Gauss, deliberately set forth in this new world and found that the journey was pleasant and beset with no precipices. Riemann a little later created a third world of geometry, which has in it no parallel lines, no similar figures, nor any solitary wastes of

infinite space. And these three mutually exclusive worlds are now at hand, incompatible with each other, each as infinitely logical as the others, each as fully capable of being the reality of the space we face every day as the others. Riches indeed we now possess, far beyond the dream of Parmenides, for even though the stately architecture of each of these worlds is far more abiding and permanent than the Parthenon itself, yet the three can not exist together, and experience is powerless to tell us either which one is the geometry of the world we live in, or to explain then whence arose the other two. To state the whole matter more accurately, we are forced to conclude that neither one of the three is a reality of the sensible experience we have, but is purely and wholly a creation of the mind, which it may apply to space to some extent, but which is after all neither *a priori* in the mind nor *a posteriori* to fact. They are the result of that quality of mind which refuses to be the sport of the winds of destiny, tossed about in the whirl of phenomena like a dead leaf, and equally refuses to be the prisoner of a granite objectivity, crystallized by the pressure of the eternal ages. The face of the sphinx, whether quarried out of the foundations of the world or moulded out of the flowing cloud, is not fashioned by nature at all, but by man.

There is in geometry, however, a still more striking verification of our thesis. This is the invention of four-dimensional space, and in general of N-dimensional space. Even Aristotle conceived of more dimensions than three, for he concludes that there is no transfer from solid to another kind, similar to transfer from area to solid, and Ptolemy undertook to deduce this result. Up to the period of the Reformation algebraic equations of more than the third degree were frowned upon as having no real meaning, since there was no fourth power or dimension. But about one hundred years ago this chimera became an actual existence, and to-day it is furnishing a new world to physics, in which mechanics may become geometry, time be coordinate with space, and every geometric theorem in this world is a physical theorem in the experimental world we study in the laboratory. Startling indeed it is to the scientist to be told that an artificial dream-world of the mathematician is more real than that he sees with his galvanometers, ultra-microscopes, and spectroscopes. It matters little that he replies, "Your four-dimensional world is only an analytic explanation of my phenomena," for the fact remains a fact, that in the mathematician's four-dimensional space there is a space not derived in any sense of the term as a residue of experience, however powerful a distillation of sensations, or perceptions, be resorted to, for it is not contained at all in the fluid that experience furnishes. It is a product of the creative power of the mathematical mind, and its objects are real

in exactly the same way as the cube, the square, the circle, the sphere, or the straight line. We are enabled to see with the penetrating vision of the mathematical insight, that no less real, and no more real, are these fantastic forms of the world of relativity, than those supposed to be uncreatable or indestructible in the play of the forces of nature. Exotic orchids of the human mind, brilliant with hues no painter ever saw, perfumed with a fragrance that no chemist can extract, beautiful with a symmetry that no draughtsman can depict, fascinating with suggestions of undeveloped powers of the human soul, the creatures of this world have shown man definitively that he is superior to space and time and given him a freedom that is beyond even his highest dreams.

Again, with forceps whose delicacy is infinitely greater than that of the tools of the most skilled workman, the mathematician has put together points like glittering beads, on golden wires whose curve is nowhere viewed with the physiological eye, for these curves may have nowhere a definite direction, they may occupy every point of a square area, they may leave empty positions on the wire infinitely numerous, they may even leave every bead at a finite distance from its neighbor and yet occupy every position, they may have direction, but yet nowhere have a definite curvature—in short they are of such intricate workmanship that it is impossible to deduce their properties by inspection. No physiological experience ever furnished any knowledge of these delicate jewels, no brain-cell or ganglion is their case, yet they are among the finest ornaments of Mathesis, Sophiæ Germana. The creation of lines of this type, or from an analytic point of view, of functions of this type, whose properties are not only not intuitively evident but in many cases are directly contrary to what one might expect intuitively, is another indubitable example of the fact that mathematics creates its objects and studies them with an internal eye whose analyzing power is increasing day by day, beyond all limits of light-waves, or intra-molecular structure, beyond all imagery, with more certainty, however, than even the best physical apparatus can enable the physicist to handle the invisible, intangible, and unperceived ultra-violet or X-ray.

We might proceed to inspect other divisions of mathematics and should find always the same conclusion. In every direction in which we might travel we should always come to the vague, the chaotic, the tangle, the unformed, but under the magic wand of the mathematician we find the vague assuming form, the chaotic appearing in order, the tangle turning into a beautiful lacework, the unformed showing first a line, then a net, then structure. Wherever the mathematician meets nature and follows her suggestions he idealizes the phenomena into something intelligible, he paints a picture of a reality he creates

as having in it a structure which matches the phenomena. Measures are made exact, laws become definite, terms are dazzling with new meaning, formulæ become alive. He comprehends physics in the calculus of variations, this in turn he includes in the functional calculus; he reduces mechanics to geometry and geometry to analysis. He solves problems in phenomenal space by his imaginary space, and calculates real numbers by the square root of minus one. A wizard, nor a sorcerer he, for his results are abiding. He is an artist who molds the phenomenal world into forms of statues and makes even more beautiful figures out of nothing at all. He is like the artist of the Beautiful in one of Hawthorne's inimitable tales, who made a model of a butterfly, so delicate in mechanism, so perfect in poise, as it fluttered around with its purple and gold-speckled wings, that the observers fancied it must be a living butterfly. The beauty faded and the mechanism lost its power on the finger of the skeptical watchmaker, who appreciated only his mechanisms of wheels, it glowed and became vigorous on the finger of the naïve child, it delighted the blacksmith, the builder of engineering structures. When the child clutched it, fancying that the beautiful toy might be his own selfish possession forever, it was crushed into a heap of glittering fragments. The artist placidly looked at the destruction, whence the beauty and the utility had gone forever, undisturbed because he knew that he could at will create even more perfect mechanisms, not because they would be more like living creatures, but because they would be more beautiful. Even though not butterflies, they delighted man more than the butterflies.

III

We turn to the consideration of the theme, what is the real in science? with the meaning of the real in mathematics as a guide to the proper answer to the question. We may begin with the oldest part of physical science, going back twenty-two centuries, to the city of Syracuse, where the conquering hosts of Rome have sacked the city, and we see an enraged Roman soldier attack and kill a dignified old man who has been busy with diagrams and surrounded by mechanical inventions of various kinds—Archimedes, in fact, the founder of mechanics. Him we remember indeed while the names of the Roman conquerors have sunk into a just oblivion. His determination of the gold and silver in the crown of King Hieron is mentioned in many a school reader, and the joyful cry "Eureka" has echoed again and again in the laboratories of the world. He idealized the lever and worked out the properties of this imaginary weightless, rigid, segment of a straight line. Since that first bold substitution of an ideal, axiomatic lever for the bar of wood or iron, mechanics has again and again idealized the objects it meets

in nature and to such an extent that rational mechanics is really a branch of mathematics, while applied mechanics points out how closely approximate the results are when attached to material objects.

A stretch of seventeen centuries follows with little advance, up to Leonardo da Vinci, artist and scientist, who with Stevin of Bruges, begins the development of statics. They were followed very soon by Galileo, the first to conduct extensive experiments for the purpose of bringing his idealized phenomena into close harmony with the material phenomena. We see him dropping shot from the tower of Pisa, rolling balls down inclined planes, counting the oscillations of the chandelier in the cathedral, finally with a flash of intuition announcing that a body in motion will remain in motion, and at rest will remain at rest, unless acted upon by some force, thus creating at one stroke two of the entities of modern physics, inertia and force. Bold indeed from a few experiments, on a few objects, to announce for all the world such laws, and to assert that all kinds of matter possess something called inertia! Inertia and mass were long synonymous, and the scientists soon accepted mass as the quantity of matter itself, whatever its kind. But we have come to see a difference between mass and inertia and we may now ask if an electron has inertia, and what kind of thing inertia must be that it is possessed in common by gold, radium, helium, hydrogen, uranium. Does the nucleus of an atom have inertia, and is the nucleus nothing but inertia? If one were on the moon, or the sun, or the lost Pleiad, would these same things possess inertia? Who knows if a particle moved in a line for billions of years in purely empty space whether would it come to rest, or always move on and on without limit? If the inertia of an electron is only apparent and due to the fact that a moving charge generates a field which retards the charge in its motion, why may not all inertia be of the same character, and thus be as fictitious as the added mass of a sphere moving in water?

The year of Galileo's death was the year of Newton's birth, titanic successor to a giant predecessor. His intuition was even bolder than Galileo's, for he conceived the entire universe as knit together with ideal threads. This ideal object he called gravity, the most universally present force, and the one we are to-day most ignorant about. This mysterious object of dynamics reaches to the uttermost confines of the universe so that the quiver of an eyelash is followed by a shivering of all the particles in the magnificent sweep of creation, yet so tenuous is it that nothing seems to interfere with its passage. The huge ball that carries humanity as well as the crater-rimmed satellite that sends its soft glow down to summer-strewn banks, cast no shadows in space under the stream of this penetrating essence of Newton's mind. The radiation of the brilliant star of day is stopped completely by either of

these, and the long shadow trails for millions of miles like a gigantic crayon which marks every object it touches; the X-ray finds its path even among the molecules of the crystal, yet is finally stopped by all kinds of substance; but this creation of the great genius of mechanics—what shall we say of it? The electron in its dizzy spinning and the stately Neptune in his many-yeared cycle, the sun in his wanderings and the nebula in splendid isolation, all alike are mastered by this immaterial, spirit-like, purely ideal creature. And is gravity a kind of matter? So Le Sage thought, but few would agree with him. Does gravity pull on the electron? Who knows? Newton did one thing whose import was not at first perceived, namely, to lay down a universal law that mass, or inertia we may properly say, is measured exactly by acceleration, and in fact accelerations are the only entities that need enter the equations, inertia becoming a mere numerical ratio. Is it possible then that the rock-ribbed hills, the stately palaces, and the gauze of the comet, all alike, are but such stuff as the mathematician dreams of, and the reality is a ratio? Indeed the modern physicist thinks he has shown that even this ratio is variable, depending upon the velocity of the moving point which has been substituted for the material particle. Gravity is not matter, and inertia is a ratio! But this virtually is saying that the world of mechanics is purely an ideal world, created by the physicist's mind in precisely the same way that Lobachevsky or Riemann created a non-euclidean world. Neither is more real than a cube, and either is real in the same way a cube is real.

Since Newton's day the other conception, force, has been extended to a great variety of phenomena, so that we have had force of cohesion, force of electricity, force of magnetism, force of chemical affinity, force of elasticity, and still others imaginable. Mysterious fingers were at every point in space ready to clutch the appropriate object of their desire, were it particle of matter, electron, magneton, molecule, or atom. The force of gravity was pulling all the time on every one of us to keep us from falling off the earth, the cohesive forces were keeping us from being shattered into dust before our time, the chemical affinities were at work building up the compounds of which we consist, and the tremendous play of these giants struggling against each other throughout the universe preserved us from chaos. They represented a premodern transformation of the nature gods of early history. For the modern physicist has abolished the once real forces, and no longer imagines space as full of the invisible fingers the giants once had. Like the childish dreams of fairies who did things secretly that man could not do, these naïve conceptions of the physicist and chemist have given place to others which are supposed in their turn to represent reality. Is there any better example needed of the creation of an ideal

reality which was relegated to the museum when no longer useful in the handling of phenomena? Inertia a ratio and force expressed completely in terms of change of position in space—the dream of Pythagoras realized in one, that of Heracleitos in the other. Where is the unchanging reality Parmenides asked for? Is it true that we can only say of two dust particles that they gravitate, that is move towards each other, of two electrons that they move away from each other, of atoms in a benzene molecule that they form a stable group, and, though stable, are in an incessant and intricate waltz figure forever shifting its diagram? When a huge charge of nitroglycerine explodes and shatters the surrounding objects, can we say nothing more than that the atoms of nitroglycerine separate under certain conditions in the neighborhood? Is it possible to reduce all physics and chemistry to the calculation of a function of each point in space called the potential of that point, a function depending for its value upon all the points in space where matter or electricity or other object is situated, a function to be determined in all its non-singular points by the position and certain numerical values associated with the position of all its singular points? We have used the gravitation potential, the electric potential, and the magnetic potential, and we might add the chemical potential, as a matter of convenient mathematics, but what if potential is the only reality? At least it is as real as any other conception we have of nature, yet no one has ever thought of it as other than a mathematical term.

The year Illinois was admitted to the galaxy in the blue sky of the American flag, was born the man who should not only revolutionize many of the conceptions of physics and chemistry, but should revolutionize the whole of natural science. Before his time there had existed an imponderable, invisible fluid called caloric, to which was due the phenomena of heat. We still have treatises on the flow of heat, in which the equations refer to a continuous fluid. But the famous experiments of Joule brought forth a new reality called energy and the law of the conservation of energy, said to be the grandest achievement of the human mind. Sublime substitution of the more unknowable for the unknowable! Sublime determination of the one great reality of nature which persists through all the swift transformations of atom, molecule, cell, or universe, from the meanest flower that blows to the most infinite nebula seen or unseen! Energy is that which can neither be created nor destroyed, the great god Proteus, changing in a flash his form so that he may not be recognizable, who may hide utterly so that his presence is unsuspected, yet in a twinkling may let loose his awful power and rend the visible universe. Energy was nascent in the phlogiston of the eighteenth century, for phlogiston was what escaped during the burning of substances, but phlogiston was a substance, and when

it was proved that it had no inertia, it was also stored away with the other models of man's creation as no longer of use. Energy can not be measured, neither weighed, nor seen under the microscope. Its presence can not be detected by an apparatus. Like the velocity of the earth, we know nothing about it directly. It is not involved in any of the phenomena of sense. It is not an inference from the observations nor experiments of the laboratories, such as the velocity of the earth may be. It is a direct creation of the human mind as much as the square root of minus one. When we have ascribed certain physical or chemical changes to the transformation of energy, the residue which is unaccounted for is ascribed to some new form of energy. We invent these forms as we need to make the law of conservation of energy hold good, and we demolish them as we find that we can account for phenomena with fewer forms that energy may take. We observe motion and we ascribe energy to the moving points, kinetic energy, depending upon the square of the velocity. The point may stop and the energy be gone, but then we say it has become potential. We always have an unlimited supply of kinds of potential energy to draw upon. We have potential energy of gravity, the energy a stone on a cliff has because it is on the cliff; the potential energy of an electron, the energy it has because of its situation as regards other electrons; the energy of an electric field, or a magnetic field, both purely immaterial mathematical fictions, is potential; the energy let loose by the high explosive shell that screams over the battlefield was potential energy. But most astonishing of all we may describe mass as merely energy per velocity per velocity. The most unknown reality of nature enables us to define that which we might suppose to be the most known reality of nature. Yet it is not matter that interests the future of the race, but energy. By it we live and move and have our being, and when we can no longer control energy we must perish. Profligate sons of Pan, we gaily spend the stores of energy slowly accumulated by mother earth, nay more we almost deliberately waste the stores of obtainable energy. We see already the darkening horizon of the future when coal will be gone, oil and gas fields exhausted, and we are even now desirous of robbing Niagara of its beauty that the sale of energy may fill pockets with gold. We see many a Swiss valley with a glacier at one end and nitric acid at the other. We build dams like cliffs to utilize the kinetic energy of the white coal, we rob the winds of their store, and we would chain the ocean wave to a treadmill.

We may even go further and say that there is no potential energy, but that all energy is the energy due to motion, even though the moving points may be hidden so that their motion is simply assumed. We have done this in explaining where all the heat energy goes when a gas

receives heat. Some of it causes the molecules to move faster, but some of the heat, and in complex cases much of the heat, becomes energy of rotation of the molecule and energy of the motion of the atoms within the molecule. In fact, if enough heat is supplied the molecules may be broken up. When we come to the atom, however, which is itself conceived to be a system of swiftly rotating electrons with a positive nucleus, we find that heat can not be transferred to it, in fact so far man has been unable to interfere with the structure of the atom. Yet in the case of radium every one knows that we have as unstable a system as a nitroglycerine molecule, and that the atom breaks up by expelling every so often electrons, and every so often helium atoms. The amount of energy let loose in this way is enormous, in fact the whole earth with its volcanoes and geysers, with its earthquakes due to internal explosions, is getting hotter and hotter from the radium explosions within, and the accumulation of energy may sometime cause the entire planet to explode. What kind of a motion is it that can be so vigorous as this, inside the infinitesimal space that an atom occupies? If the potential energy is after all only the energy of these invisible motions, how enormously fast it must be!

In connection with the transfer of energy, as from the sun to the earth, we find the creation of a medium called ether. It seemed inconceivable that energy, if it be only motion, could get from the sun to the earth without anything to move in the interval. At a speed of 185,000 miles per second this medium transmits radiation of all kinds, whether light, heat, or the wireless wave. The auroras of the northern sky due to the magnetic energy that arrives from the sun when some cyclone of terrific power shoots out its winds of intensely hot hydrogen for hundreds of thousands of miles, the ceaseless flow of waves of energy as the electron circles around its nucleus billions of times in a second, waves that impinge upon matter like the waves of the ocean upon a mass of rock, capable of setting matter in motion by their pressure, all these surely need a medium to transmit the energy if it be motion, that is, kinetic. But the modernmost science sees no further need of this medium and it may also be put away with other discarded models the mind has made, for if it does not exist save as a conception, how can it be a reality of any type but mathematical? In fact it is still simpler to consider that energy itself moves in empty space, and that a wave consists of a current of energy that waxes and wanes, rising to a maximum and sinking to zero several billion times within a second. This current of energy has a momentum, which is the quotient of the energy density by the velocity, and a mass, which is the quotient of the momentum by the velocity. Thus an electron is reduced to moving energy, this energy having a central point which it does not

reach, the intensity of the energy varying as the inverse fourth power of the distance from this center, the center being surrounded by a sphere of discontinuity at which the energy becomes zero on one side and a very great value on the other. If it be possible then to reduce all electrons to energy distributed in space in this manner, and all matter to aggregates of electrons, we obviously have come finally to Parmenides's vision of the one substance of being. And we might also say that we have realized Heracleitos's vision of the Fire whose fixed measures are always being kindled and fixed measures going out. What a perfect chaos of change the universe becomes, for at every point we see the streaming energy from an infinitude of centers, flashing through space with the enormous velocity of light and producing at each fixed point such an intricate function of the time that we fail utterly to get any picture of the phenomena! And the rotating electron, so rich in this cosmic matter, which it radiates at every whirl with tremendous prodigality, must inevitably slow down as it loses its energy, and ultimately become stationary, and thus nothing at all, unless from some other blazing center it receive a new life. Besides this there are all the moving clusters of energy traveling through space on their own account, with no such attached discontinuities as electrons. Whether energy is granular or continuous is of little import as far as our problem is concerned, the reality of energy being the only question, and if this reality reduces to a non-substantial energy as the only being then we have a reality whose difference from the mathematical type is not obvious.

We have frequently mentioned the electron and the nucleus, other creations of the human imagination, things we can not ever hope to see, existences which we postulate in order to account for phenomena. The new science of radioactivity has produced these objects. The electrons are of the nature of negative electricity, the nuclei are positive, so that the substance electricity has been put in the museum of antiquated models of thought, and neither the one-fluid idea nor the two-fluid idea of electricity is anything more than a useless mathematical model. When will the day of doom of the electron and the nucleus come, and these too go the way of all such constructions of the intellect? And yet when we see the scintillations of the fluorescent screen near a particle of radium it is very convenient indeed to imagine the terrific bombardment of the high-power guns of the minute atoms as they explode their smokeless powder. A nucleus may be a system, but whether an electron is a single thing or a system we can not imagine, and for the present the model is that of a sphere or an ellipsoid, though upon occasion who doubts that we would cheerfully make it over into a whole solar system? We are just now endeavoring to discover whether we

had better endow the electron with inertia or not, with weight or not? The nucleus seems to carry all the weight of the atom.

The chemist has also had his turn at playing with the toys of mind. His molecules he long ago considered to be a handful of round pearls of thought, which he strung into necklaces for the adornment of Scientia, necklaces which consist of chains, with pendants, fantastic clusters, and other figures so mathematical that the great Cayley studied the whole subject as a piece of mathematics. His pearls have turned out not to be pearls, but to be tiny solar systems, so that Scientia is now adorned with strings of universes. These tiny solar systems contain valence electrons whose attractions and repulsions have replaced the chemical affinities. We need not elaborate on the situation, but we must wonder what the diagram will look like a thousand years from now. He has dispensed with eighty or more kinds of matter, save as a matter of convenient language, and is now describing the eighty or more kinds in terms of a few nuclei and electrons. Perhaps he can dispense with the nuclei if he can imagine an intricate enough arrangement of points to take its place, and let the whole universe be described in terms of energy alone, or of mere granules of ether alone, with high velocities to furnish the phenomena of change. The atomization of mathematics has passed the meridian, but that of science is at its zenith.

When we turn to the phenomena of life, the study of the biologist, we find the realities no different. At present he is endeavoring to his utmost to express all these in the same terms that the physicist or the chemist uses, partly in the vain hope that when they are so expressed he can predict what kind of an animal, whether an elephant, a man, or a bacterium, will be the result of bringing together so many molecules of this or that, and so much energy of this or that type. He sees perhaps that to create magnetism where none existed, all that is necessary is to start an electron or even a mere mathematical line of electric force moving, and presto, the magnetism is at hand; so he hopes to rival this magician's trick with one of his own, and by setting electrons and atoms into some kind of motion, arrive at life. Perhaps life consists of such a combination! It may be that there was first a universe filled with granules of nothing at all, mere points, that moved with the velocity of light in all directions, thus having tremendous kinetic energy, or just energy let us say. Perhaps some of these lost some of their velocity, not for any reason or on account of any cause (for such terms are philosophical and forbidden in science), but they just did. The energy being indestructible, exercised its protean prerogative, and changed its form, becoming potential energy, and the thing that now moved was an electron, moving potential energy. Perhaps these electrons in turn congregated accidentally into systems, some of which turned out to be unstable and broke up, some of which were stable and became what we

call atoms. Perhaps the atoms in their Odyssey found other atoms, and with no cause whatever, they joined themselves together because the combinations were stable, that is, did not break up. Perhaps these molecules, as the æons rolled along, also found certain groupings were not broken up, but persisted, always with the accompanying accumulation of potential energy, the potentiality being merely the fact that they did not break up. Perhaps it was the fate of these multimolecules of the colloidal state in the strange caprices of chance to find that some of their combinations were willynilly stable, and were later to be called cells by the scientists. Perhaps the cells became organisms and living creatures. The living creatures during untold and unimaginable periods of time have themselves become more and more intricate, and some of them now group themselves into societies and nations. Yet somehow in all these wild saturnalia of chance, it seems the steady drift has been to form the more and more complex, the more and more highly organized in which the adjustment of the electrons, the atoms, the molecules, the multimolecules, and the cells, is more and more delicate, but, strange to say, more and more persistent. Yet the biologist must admit, what he is reluctant to admit, that when we get to the complicated process of cell-division we must label some of the energy biotic energy, for it is unlike the previous forms. This ought not to be surprising, for if the mere motion of electric energy in space somehow creates instantaneously a certain amount of magnetic energy, neither being quite statable in terms of the other as to kind, we ought not to be startled if in all this long chain of evolution, there should come some day a further form of energy. Convertible of course into the other forms of energy, otherwise it would not be energy, but yet different in kind. We can not help wondering too what peculiar numerical combination always loaded the dice in the game, so that the *complex* was the inevitable result. In mathematical probability we expect homogeneity to result from the chaotic mixture of any set of points with any kind of velocities, not heterogeneity; and even the second postulate of thermodynamics says that entropy tends to a maximum, which is simply the same as saying that in a big enough chaos, everything tends to homogeneity, mediocrity, a dead level. We feel somehow compelled to think of Maxwell's demon as opening the gates for those motions which tended to complexity, and shutting it to those which tended to entropy. So here is a further element that we must put into our model, the feature of evolution, one that so far the physicist and chemist has no need of. This evolution we must call a creative evolution, because we pass from the less complicated to the more complicated. This creative evolution becomes as much a reality as any of the other things we have mentioned. Whatever we are obliged to use in the construction of our model of the universe is a reality of science.

When we no longer need it, it does not cease to have reality, any more than a cube goes out of existence when we study spheres.

The new feature of the model has been called vitalism, a vague term too much associated with phantasms; and entelechy, a more technical term. Entelechy is not more Hellenic than entropy, and hence we need not be frightened at it. It is the formative character of the living thing, that which tends to produce the complexity. The entelechy of a circle is the line which makes the points of the circle into a synthetic whole and not a mere aggregation of points. Some mathematicians, it is true, consider that a circle is nothing but a series of points; some physicists consider that the aggregation of electrons and nuclei is an atom; some biologists consider that the aggregation of multimolecules is a cell; but the modern theory of functions of lines thinks that a circle is more than its points; and the explosions of the radium atom show that there is a stability which may let go and the mere electrons and nuclei cease to be radium; the organizing power of cells, their reproduction, their self-repair, their storage of energy of various forms, their ability to increase their potential characters, whether of energy, motion, or structure, demand that we put entelechy into our image of the universe. What is entelechy? is no more foolish a question, and no less foolish a question, than the corresponding one, what is energy? When we have a way to measure it, it will be used just as much as energy. And it seems obvious that entelechy will have to start with the electron and the atom.

There is still another series of phenomena which the scientist is obliged to study, and in which he might hope to have more success than in those previously mentioned, for they seem to be so immediately close to him that they are part of him. The phenomena of mind ought to be those indeed which the intellect could lay hold upon and strip to their ultimate reality. But here too we see the same procession of models rather than ultimate realities. We must content ourselves with an imitation, or shall we say that what we can call real is only that which we create, and that the real would not be at all if we did not create it? There once used to be in this science a soul, a subtle fluid or spirit, that permeated the whole man, which persisted even after cells had broken down into molecules, after entelechy had ceased to form. We need not pause to study the progress of philosophy and science which annihilated the soul, or rather put the soul into the museum. Mind took the place of soul, a substitution of a more vague term for the vague term soul. Mind was complex, but it was for a time an aggregate of faculties, perception, conception, imagination, judgment, reason, will, memory; and educational systems to-day preserve these divisions. Mind was also constructed out of ideas, linked together in associations which were indissoluble, a vast Pandora box, which occa-

sionally opened and allowed some of its creatures to escape for a time into the air of consciousness, in groups that were too often made up of as many undesirable elements as desirable ones, but always being stored away again in this ever-accumulating aggregate of experience. Mind was later merely an aspect of the central nervous system, and the model became that of the net of nerve cells and their neurons and dendrons—a very mechanical model, and one most facile in "explaining" the phenomena of psychology. If the system split into two sets of cells, isolated from each other, then there were two minds, two personalities in the same body. This model too went its way, to the museum, and the new model was a stream, the everlasting flow of Heracleitos. Like the wraiths of morning mist on the mountain lake, fading away from sight even as they come into view, the wisps of the processes of consciousness are vanishing even as they appear. Just as the biologist might consider that life is merely a series of secretings, circulatings, respirings, digestings, this model of the psychologist's making is only a sequence of happenings. The dream is only the dreaming, the symphony only the playing, the ache only the aching. Like Prospero's magic everything disappears with the thinking. In conclusion we have one more model of mind, which preserves its stability, its entelechic organization of experience into personality, its directive and selective character, its purposiveness, and adaptation of means to an end. Mind becomes a creative agency, and its evolution from the void into the determined, undaunted creature of to-day becomes the story of the universe. Tense with activity, from its bonds it creates spaces and times, from the universe worlds of intellect, from star-dust Pleiades; it makes the winds of eternity carry its wings, it floats on the waves of the stream of phenomena; it touches matter and energy, life and mind, and the Queen of Beauty steps forth, never to sleep again; it plays on the pipes of Pan, and circling electron, blazing Sirius, throbbing cell, and wandering creature, burst forth into music; to intellect it adds intuition, to understanding sympathy, to contemplation creation. No longer does the tantalizing search for the reality of the swiftly fading vision it once had by its flickering waxlight continue, for Psyche has become a goddess, and beholds Eros forevermore.

"MEMBERS ONE OF ANOTHER"

By Professor B. W. KUNKEL

LAFAYETTE COLLEGE

EVER since the beginning of the war in Europe, the rest of the world has seen what marvels the cooperation of practically all citizens can accomplish at least in the matter of man's control of his environment. The significance of this, I believe, is not far to seek. It lies in the strong probability that man has evolved not so much as an isolated individual as a part of a greater organized group which the Germans worship as the state, but which I feel inclined to call simply the human association in order not to prejudice my cause before getting under way. When we say that man or the horse or the lobster has evolved, we ordinarily think of the evolution of the individual man or horse or lobster. But, while you and I have been evolving, there has been going on another kind of evolution, less obvious, but quite as important. The evolution of the whole body means the evolution of cells and organs, but the cells have been evolving in order to perfect the individual and fit it more completely to its environment. The individual organs lose their independence but the society of cells and organs is better fitted to survive. You and I have been the objects which are fitted to survive in the struggle for existence and not our eyes and teeth and stomachs. But, as we shall see later, in some cases it is evident that the individual animal has not been the unit which has been best adapted to its environment, but a group of individuals which survives in competition with other groups. The association of animals may be the evolutionary unit quite as truly as the individual; in the same way that the individual body is the evolutionary unit rather than the specialized organs and cells making it up. The question I would raise, then, at the outset, is, has man evolved as an individual or as a part of an association? Are we "members one of another," as the Apostle Paul seemed to think, or are we individuals having no relation to our fellows and answerable to no one, after the fashion of Nietzche's supermen?

The problem is readily seen to be far-reaching. Its bearing upon our social and political organization, religious beliefs and moral code is intimate. In the light of human evolution, is humanity destined to become more closely socialized or less so, is individual effort to become more or less individual in its returns, are national boundaries to hem their citizens in more tightly or are boundaries to break down eventually? It would be manifestly impossible within the scope of a single paper to touch upon these far-reaching problems. I would attempt

something far less comprehensive and simply point out some of the traits of man's immediate ancestors and what seems to me to be one of the most important factors which have brought about his evolution.

Before considering the evolution of the human race, one or two phases of the general phenomena of evolution must be discussed, for without this explanation the more specific problem of man's evolution will not be so clear. Evolution results in greater adaptation to environment, in bringing the individual into a more intimate relation with the world outside itself, or in giving it more abundant life. Adaptation, or fitness for a particular niche in nature, has been the end of evolution, for extinction has been the fate of those forms which do not fit into their place in the world and which succumb in the struggle for existence. In general, this adaptation has been effected by specialization of parts with division of physiological labor, and therefore greater interdependence of parts. But there are numerous instances, especially among parasites, in which the course of evolution has been in the direction of degradation of structure and loss of specialized organs.

The Protozoa with their generalized structure and activities lost the capacity of independent life as soon as they began to form a Metazoon. Each of the generalized cells constituting a Protozoon has all the general functions of the most complete animals; each cell can take in food, digest it, assimilate it; each cell is responsive to changes in the environment, such as changes in light, temperature, density, and chemical composition of the surrounding medium; each cell grows and reproduces itself when the limits of growth have been reached and takes on a new lease of life by the act, an immortal bit of protoplasm. As soon as cells, however, begin to be specialized, the activities are curtailed, so that some become far more evident than in the generalized Protozoa. In the simplest Metazoa, like the freshwater *Hydra,* certain cells become specialized to digest food, but lose their power of movement, while others which come in closer contact with the environment—those covering the exterior of the body—become more resistant to mechanical disturbances and more capable of movement. Each group of cells making up the *Hydra* has lost some of its primitive functions, but has become more alive by association with other specialized cells. With further differentiation, the activities of the different organs become more circumscribed, so that here the power of secretion is lost, there the power of movement, and in another organ irritability to this or that form of stimulus—our finger tips are not sensitive to the perfume of the rose, nor our ears to its color.

The cells which were, in the very simplest types of animals and plants Jack-of-all-trades, can not exist, when specialized, apart from their fellows, which all contribute to the general welfare of the whole. "The eye can not say to the hand, I have no need of thee; or again, the

head to the feet, I have no need of thee." The perfection of the eye is possible only because the needs of this organ are supplied by a great variety of other parts. We can only smile heartily over the naïveté of Empedocles of Agrigentum, who may be called the father of the evolutionary idea, who thought that animals first appeared, not as complete individuals, but as parts of individuals—heads without necks, arms without shoulders, eyes without sockets. We are forced to regard the eye as evolved not as an independent structure, but simply as a part of a whole organism. The needs of the whole organism have been more perfectly met as a result of the specialization of the parts, and not the separate needs of the individual parts. Everywhere an evolution of separate parts in order that the individual organism may be better fitted to its environment has been going on. The brunt of evolution has been borne by the individual and not by the separate organs. Have we any indication in nature of larger organized beings than the individual person, namely communities or colonies which have borne the brunt of evolution and which have evolved at the expense possibly of the individual parts composing them? Is the relation of the individual man to the association comparable to that of an organ or cell to the body?

There is, of course, a certain biological similarity between the individual organs of the body and the body politic, as Thomas Hobbes developed as early as 1651 in his book, "Leviathan," and which has been discussed by many others more recently, notably by Herbert Spencer. The organs are masses of material specialized to perform certain functions which extend the life of the whole body and are mutually dependent on each other. The society and the individual body both grow from small beginnings which exhibit no specialization at first, and gradually attain greater and greater specialization and interdependence of parts. The similarity between the organs or cells on the one hand and members of an association on the other is heightened by the fact that there is a certain competition or opposition among the cells just as there is among the citizens of a healthy state. The gymnast's arms grow and become strong while his legs and brain may remain feeble, because the limited amount of nourishment which the body is able to absorb is diverted to the arms. As Ernst Haeckel says in the opening chapter of the "Riddle of the Universe,"

> We can only arrive at a correct knowledge of the structure and life of the social body, the state, through a scientific knowledge of the structure and life of the individuals who compose it, and the cells of which they are in turn composed.

Interdependence of parts and the exchange of the products of their activity, which has been called the vital circulation, are the criteria of an organism. Just as soon as the products of metabolism of one layer of cells are transferred to another layer, or as soon as food procured by one member is transferred to another, just that soon an organism results.

There are several obvious objections to the idea that the evolution of man has been as a member of a group rather than an individual, or that the relation of a man to the group in evolution has been that of an organ or a cell to the body. The loudest objection, possibly, is on the basis of the ignoring of that preeminently human trait, individual consciousness. Consciousness resides in the individual person and can not be united into a common consciousness resident in the group, but until something more definite is known regarding the nature of consciousness and the occurrence of consciousness in the lower animals, is does not seem possible to take it into consideration on a purely scientific basis.

A further objection to the thesis here presented is that while the organs of the individual body are necessary for the health of the individual, the human association finds no one individual essential for its continued health and prosperity. This objection, however, is not as valid as it appears at first hand because the comparison is invariably made between the individual composed of many highly specialized and stable organs and the association in which biological specialization, in contrast to social specialization, has been carried to a very slight extent. The discrepancy becomes rather negligible when comparison is made between a simpler, only slightly differentiated, individual and the association. Thus, the simple freshwater *Hydra* made up of two layers of cells is so plastic that it may be turned wrong side out by proper manipulation with no serious injury. In other words, although there is mutual dependence between ectoderm and endoderm and both make up the individual *Hydra's* body, both are so plastic that the one may be transformed to the other under proper stimulus. Or again the individual body of one of the higher animals may be subjected to the loss of many of its cells without suffering in any way. Portions of some of the most vitally necessary parts of the body may be removed without causing inconvenience. The idea of an individual organism, then, does not exclude the possibility of a single part's taking over the functions of others and adjusting itself to the new conditions.

As will be shown presently, more perfect adaptation may involve the single individual or it may involve the whole group or colony of individuals. In general, of course, the welfare of the race means the welfare of the individual, and the injury of the individual means just so much loss to the group; but there are some striking exceptions to this rule which may throw some light upon the problem of human evolution. In these cases the fittest which have survived are not the fittest individuals but the fittest colonies, or groups. Fitness may indeed have been achieved at the expense of the individual. The associations which show most clearly the specialization of the individual for the adaptation of the whole group are those of the lowly Hydroids and the highly specialized social bees and ants. The Hydroids are marine animals having

a plant-like appearance which abound usually in shallow water firmly attached to some solid support and covering extensive surfaces often with a furry growth, very closely related to the coral polyps. The colony is made up of countless polyps branching from each other and connected by a continuous system of hollow tubes which adhere to the solid substratum and afford communication between the separate polyps. Generally these are all alike and are able to take in food, to digest it, to throw off powerful stinging organs when stimulated, and to reproduce their kind by sending out buds like themselves, but they are incapable of locomotion. If the colony is divided, each bit is perfectly capable of continuing its existence indefinitely for each polyp is self-sufficient. From time to time, however, a different kind of individual is produced, known as a medusa, which swims away and lays eggs, but is incapable of taking in a particle of food and so is doomed to an early death. Each medusa is dependent upon the polyps for food, and might, if it did not break away from the family, be regarded simply as an organ of the more complex colony. The medusa has evolved for the extension of the colony; its own continued existence is sealed. It is the colony as a whole which has evolved as an adapted organism and not the individual polyp or medusa; just as in the bodies of the higher animals it has been the individual rather than the single organ which has borne the brunt of evolution.

An even more striking illustration of the evolution of a whole colony is afforded by the Portuguese man-o'-war, a near relative of the hydroids. In these animals the colony exhibits a permanently continuous group of individuals of various kinds, but each specialized for a particular function and evidently built on the same general plan and evolved from a less specialized form of polyp. The Portugese man-o'-war is made up of groups of defensive, nutritive, reproductive, sensory, and locomotor individuals which, unlike the hydroid polyps, have lost their power to live independently but which have been so closely united as to form organs of a single body. At the same time the structure and development of these different polyps shows beyond the shadow of a doubt that they are in reality different forms of the same individual polyps of the Hydroids.

Finally there is the case of the social bees and ants in which the social unity is so definite and perfect that the individuals are incapable of continued life outside of the colony. The queens are usually so specialized as to be incapable of procuring food and rearing young without the assistance of the workers and the workers in turn are so specialized as to be incapable of reproduction, and the drones are indisposed to exert themselves in foraging. "Associated animals," says Darwin, "have thus acquired many remarkable structures, which are of little or no service to the individual, such as pollen-collecting apparatus or the

sting of the worker bee, or the great jaws of the soldier ants." The instincts no less than the structure of the different castes of social insects are distinctly social and can not possibly have come into being except in so far as the colony has evolved as a unit rather than the individual. It is difficult to see how the instinct to sting an intruder could have been developed directly, in view of the fact that in most cases it results fatally to the bee. It is also difficult to see how the instinct to lay up food for months could otherwise have developed in an animal whose normal life is only six weeks. The different castes of ants furnish equal evidences along this same line of the direct evolution of the colony or association and the indirect evolution of the individual. Thus in certain species there are workers and soldiers with jaws and instincts more different than in unrelated species. The workers of one caste never leave the nest but are provided with food by another caste. In all these cases a division of labor is effected which is advantageous to the association of ants as division of labor also is to human beings, enabling a much larger population to be supported on a unit of surface. Complete interdependence of parts and the transfer of material from one part of the association to another indicate a very closely knit association which has been differentiated by an evolutionary process operating through the community, and not through the individual. Although made up of discontinuous masses and lacking permanent form, we must, I think, agree with both Wheeler and Julian Huxley in regarding the swarm as an organism, the product of a complex evolution.

It is perfectly evident, I think, from what I have just shown, that some organisms have developed because of the operation of the evolutionary process upon their individual bodies directly, while others have developed as subordinate parts of the whole group which has evolved as such. Of course, we can not tell why one species should evolve as individuals and another as an aggregate, but that such is the case there can be no doubt.

This shift in the brunt of evolution from the individual to the group in mankind would seem to explain the difference which Huxley made so clear in his essay on "The Struggle for Existence in Human Society."

> Society differs from nature in having a definite moral object; whence it comes about that the course shaped by the ethical man—the member of society or citizen—necessarily runs counter to that which the non-ethical man—the primitive savage, or man as a mere member of the animal kingdom—tends to adopt. The latter fights out the struggle for existence to the bitter end like any animal; the former devotes his best energies to the object of setting limits to the struggle.

In order to determine whether man's evolution has been as an individual or as a part of a group, the most important respects in which

man differs from his nearest allies among the beasts must be considered. The most essential differences between man and the apes are the upright position and general defenselessness of the body, the enormously developed intelligence with the power of speech, and a moral sense. In how far these traits are quantitative and not qualitative does not concern us here.

In comparison with the rest of the animals, the relatively weak and defenseless body is striking, especially in view of man's size which renders him unable to retreat into recesses too small for his aggressors, after the fashion of so many of the weak and defenseless gnawing mammals. Man has no defensive armor or heavy integument like the armadillo or elephant, or heavy hair to afford protection against claws and teeth. In fact, the upright position renders man especially vulnerable, although it frees the hands for the wielding of clubs or stones. The smaller base made by the two feet instead of four and the elevation of the center of gravity render man particularly easily overthrown in combat. Besides, some exceedingly vulnerable parts of the body which in the four-footed animals are protected by their position, are left exposed. The whole trunk, with its broad, flat thorax and with the abdominal organs without even a bony chest enclosing them, is especially liable to disabling or fatal injury. In addition, the superficial position of the femoral artery in the groin due to the straightening of the thigh on the hip must have been responsible for much human wastage since prehistoric time. The upright position has likewise rendered the carrying of the fetus particularly hazardous and has put such a strain on the veins of the lower extremities as to make them liable to become varicose. Weak as the human body is against attack, it is almost equally weak in offense; large teeth or strong talons, or limbs of such a shape as to be strong in relation to their weight are not part of the human equipment. Man's strength and survival in competition in nature must be attributed to his intellect and social solidarity. It has only been by man's standing shoulder to shoulder and cooperating for a common purpose that he has gained ascendancy over the beasts and become superlatively intelligent with the power of speech and a moral sense.

The biological approach through the structure, embryology, and fossil remains of the ancestors of the human race do not shed much light on the question whether or not man has evolved as an individual primarily or as a part of an association.

From the psychological avenue of approach more light is thrown upon our problem. The habits of the apes, especially the less specialized ones, those which more nearly represent the common ancestor of the human race and the larger anthropoid apes would seem to indicate a gregarious habit in man's primitive ancestors. It is only the larger

anthropoid apes like the gorilla and the orang in which the habit approaches the solitary, and these forms have very restricted ranges which would seem to indicate that they are disappearing. If man did not evolve as a part of a group, if the group were not the unit which was perfected for the struggle, much of the peculiarly human psychical activity has no meaning. The moral sense and the power of speech, man's most distinctly human possessions, could not easily have come into being apart from a social life in a community of interdependent parts.

Darwin has summed up the evidence regarding man's ancestors as follows:

> Judging from the habits of savages and the greater number of Quadrumana, primeval man, and even his apelike progenitors, probably lived in society.

Darwin even went so far as to suggest that man sprang from a comparatively small and weak species rather than a powerful one like the gorilla since it would have necessitated the development of social qualities which led him to give and receive aid from his fellow men.

> An animal possessing great size and strength and ferocity, and which like the gorilla could defend itself from all enemies, would not perhaps have become social; and this would most effectually have checked the acquirement of the higher mental qualities such as sympathy and the love of his fellows.

The moral sense is a natural and inevitable development from the social instincts and would have been acquired by any animal endowed with well-marked social instincts, including the parental and the filial affections, as soon as the intellectual powers had become as well developed as in man. As Darwin has shown, the social instincts lead an animal to take pleasure in the society of its fellows, to feel a certain amount of sympathy with them and to perform various services for them. Horses and cattle are known to lick and nibble each other in smoothing their coats, and monkeys are prone to help each other to remove vermin from inaccessible parts of their bodies, and in some instances it has been observed that they remove burs and thorns from each other. Then, as soon as the mental faculties had become highly developed, images of all past actions and motives would be passing through the mind of each individual and that feeling of dissatisfaction which invariably results from any unsatisfied instinct, would arise, as often as it was perceived that the enduring social instinct had yielded to some other instinct. And still later after the power of language had been acquired, the common opinion how each one ought to act for the public good would naturally become in a permanent degree the guide to action. In other words, the social instincts are the necessary and sufficient conditions for the evolution of a moral sense.

Alfred Russel Wallace expresses the same truth as follows:

> The moral sense in man has developed from the social instincts and depends mainly on the enduring discomfort produced by any action which excites the general disapproval of the tribe. Thus, every act of an individual which is believed to be contrary to the interests of the tribe, excites its unvarying disapprobation and is held to be immoral; while every act, on the other hand, which is, as a rule, beneficial to the tribe, is warmly and constantly approved, and is thus considered to be right and moral. . . . The social instincts are the foundation of the moral sense.

The moral sense has no significance from the point of view of the individual, but only from that of the larger association for

> although a high standard of morality gives but a slight or no advantage to each individual man and his children over the other men of the same tribe, yet an increase in the number of well-endowed men and advancement in the standard of morality will certainly give an immense advantage to one tribe over another. A tribe including many members who, from possessing in a high degree the spirit of patriotism, fidelity, obedience, courage, and sympathy, were always ready to aid one another, and to sacrifice themselves for the common good, would be victorious over most other tribes.

Furthermore, no tribe could hold together if murder, robbery, treachery, etc., were common within its limits.

Thus it would seem that the presence of a moral sense in man presupposes a group intimately associated, and more or less interdependent, and that the evolution of a moral sense results in the better adaptation of the group rather than of the individual. One of the few really distinguishing features of the human race, morality, could not have evolved had there not been the necessity for an association of mutually dependent individuals.

Together with a moral sense, the power of speech distinguishes man from the lower animals. And just as the social habit was necessary for the evolution of morality, it was absolutely essential for the development of language. It is scarcely necessary to indicate so obvious a relationship. It has the same function in the community that a nervous system has in an individual body, for, by means of it, different parts of the organism are brought into relationship with each other and a change in one part is transmitted to a widely different part for the accomplishment of some purpose by the larger group. Just as the nervous system unifies or integrates the individual body, language brings the association into harmonious action. As Professor Sayce has said in his "Introduction to the Science of Language," "Language is the creation of society."

Once the human species ceased to be *Homo alalus,* the stimulation of one part of the social organism called forth action in a different part and the whole association was knit more firmly together and *Homo sapiens* appeared on the scene of action. Language also allowed memories to be passed on so that there might be a storage, as it were, of

impressions to be released by the association at a subsequent time. Man acquired the power of directing actions within the association at a distance both of time and space and these two troublesome conceptions were to a certain extent overcome. As soon as men had to live together, and found that they could by making signs direct each other's actions, there was immediately an immense step made forward in the arrangement of propositions within our brain, as Professor Clifford has expressed it.

This very brief consideration of the way humanity may have evolved shows how fundamental the association of human individuals has been in that evolution, and how fundamentally unified a group of men must have been in order to survive. What constitutes a human association I have not discussed. It might be a single family like the Swiss Family Robinson, or a tribe, or a nation, or the entire human species. The limits can be determined only on the basis of interdependence and the so-called vital circulation. In the infancy of the human race it must have been the troupe occupying a restricted region between the members of which some division of labor and mutual aid must have been practised, at least to the extent that sentries to warn of approaching danger and signal the rest of the association may have been set, or one member may have acted as leader and directed the flight from the enemy or spied out food and shelter. However limited the association may have been in the beginning, it is needless to say that now, thanks to the greater intelligence of the human species, the association is wider as measured by the much greater interdependence and much more general vital circulation. When the failure of the wheat crop in India or floods in China raises the cost of living all over the world, and the murder of the Austrian Archduke Ferdinand in the capital of Bosnia sets men murdering each other not only all over Europe but in the heart of Africa and on the shores of Asia, it is evident that the vital circulation now embraces a considerable group.

THE RUSSIAN VILLAGE AND THE WAR

By ROBERT E. BLAKE

PETROGRAD, RUSSIA

THE average Russian village is hardly an attractive spectacle. One emerges from the forest into long, alternate strips of rye, potatoes, flax and hemp; then on the low hill in front, gray cabins and barns appear. Partly ruined and dilapidated, partly fresh and sheathed with clapboards, the houses are scattered along the line of the rut-eaten road. Encircling the shanties runs a high six-rail fence.

This is an important feature of the village, for each "court" (peasant house with outbuildings) is obliged to maintain a given section of it. Within its limits the stock are allowed to wander at will until the crops are gathered, when they are turned into the fields.

In the northern districts the shortness of the season prevents much cultivation of vegetables. The individual peasant, aside from his inherent conservatism, fears his neighbor's children. "What is the use," he asks, "of planting carrots and beets, when they will be stolen before the roots are really set?" Further south, vegetable gardens become more common. The turnip alone, the most hardy of the esculents, is grown in quantities for human and animal consumption.

The inhabitants of the village are seldom picturesque. The costumes of the men—coat and trousers of cheap woolen stuff; occasionally also of home-woven linen of a dull blue color—has no specific character. The women are clad in cheap gingham gowns; only the bright bandanna handkerchiefs give a touch of color to the landscape. The hard life, coarse food and the demon vodka have bowed the figures and lined the faces.

For one who looks below the surface, however, and has some knowledge of the conditions of Russian life, the sayings and doings of this apparently uninteresting hamlet are of profound interest. Russia is an agricultural country, and it is such humble hands as these which raise the millions of tons of grain formerly poured into the mouths of hungry Europe. It is the strong arm and patient heroism of the Russian *muzhik* which form the impenetrable ring of blood and steel which dams the Teuton flood on the western border. For this reason it is not without interest to review those changes which the war has introduced into the life of this isolated settlement, which was previously almost untouched by the currents of the outside world.

Should we happen to visit the settlement at harvest-time, we should

be struck by the predominance of women over men among the field hands. A husky *baba* (peasant woman) is hooking the hay on to the cart: two more are trampling it down. In a neighboring strip of rye an old, bent woman is swiftly and scientifically binding sheaves of golden grain which fall before the sickles of her two half-grown grandsons. Further on two young peasant women are pulling flax, knocking the earth by a dextrous slap upon the brown instep, only pausing to cast a bright eye in the direction of the travellers as the "phaeton" gallops by. It is the broad-shouldered, wide-hipped Russian *baba*, whose husband and sons have left her to shed their blood for their country on the plains and in the swamps of Poland. Bowed already by household cares, she has taken upon herself the labors of her absent men, and her strong arms, equally at home in the field and in the house, now do the plowing, sowing and reaping as well as spinning, cooking and rocking the baby.

Of course, she works under a handicap. About 40 per cent. of the draft animals have been requisitioned for the needs of the army. This has had its effect in the reduction of the total area under cultivation, which probably averages about 15 per cent. in those districts of Russia which lie outside the immediate zone of hostilities. The peasant is better off in this regard than the landholder, for the communistic organization of the village enables the available resources of stock and of labor to be more evenly distributed over the territory under cultivation. The government has helped as well by the advance of seed-grain, and to a certain extent by placing the services of the prisoners of war at the disposal of the population.

One thing has improved the situation greatly. Vodka, the curse of the population of Russia, has disappeared. The green sign of the *kazyonka* (vodka-shop) has departed for ever. This does not mean that Russia has stopped drinking—shades of Bacchus, no! There is hardly a peasant's hut in North Russia which has not three or four hop-vines growing near by, and every peasant woman knows how to brew *braga* (home-made beer). The townspeople comfort the inner man with wonderful and awful mixtures, whose basic components are furniture polish, denatured spirit and eau de cologne. BUT (and it is a very large but) these compounds to not penetrate to the remoter villages, and even if the population does indulge in a keg of beer now and then, the crops are not turned into alcohol as was the case before the war. One illustration from the writer's personal experience will show the far-reaching consequences of the measure. In one miserable village in northeastern Russia the income from the vodka-shop had been 23,000 rubles ($12,160) a year. There were 23 "courts" in the hamlet, which made the average outlay per group of families (married sons live with their parents) something over a thousand rubles a year. Granting that

the exigencies of war-time have increased the disbursements of the family to a very considerable degree both in living and in working expenses, yet one can easily understand why the bank-deposits of the small investors have increased at the staggering rate of five million rubles a month.

The cyclonic wave of refugees which swept over the eastern provinces in the late summer and fall of 1915 brought another serious problem before the Russian village. A satisfactory solution of the same was reached only by the united work of the government and of all classes of society.

The lack of ammunition had made it impossible for the Russian armies to withstand the German drive on Poland. Foot by foot, contesting stubbornly, the legions of the Tsar were forced back from the Carpathians to the Vistula, and the San, from the San to the Dvina and the Pripet. Realizing that for the enemy supplies were the essential thing, the Russian decided to remove the population from the districts which they evacuated. Houses, crops and untransportable household goods were systematically burned. The unhappy inhabitants of the western governments were despatched eastward, taking with them their stock and sometimes a few of the more valuable chattels, but in many cases having to abandon them *en route*. More often, alas, they were forced to flee, having only had time to destroy, but not to save. This tidal wave of unfortunates swamped the railroads and the larger towns for the better part of three months. Official figures give the sum as four millions, but this is unquestionably too low. When we count those who left before and make allowances for faulty registration, etc., eight millions will not be far from the truth. To properly conceive this staggering total is almost impossible for the human mind. The ghastly amount of suffering and hardship which it occasioned can only be grasped by those who themselves beheld the arrival of the refugee trains: only those who aided and assisted can know the hell through which these human beings had passed.

The overcrowding of the larger towns brought about an immediate rise in prices of food and lodgings, especially for the poorer classes. To reduce the resulting congestion, it was decided to quarter the surplus population on the villages of the eastern governments of the empire. The relatively speedy and well-arranged distributions of the refugees was carried out largely through the efforts of the two great public organizations, the alliance of the *zemstva* (the local non-municipal self-governing bodies, best to be compared to the county governments among American institutions) and the league of Russian municipalities. They have shouldered a large share of the burdens which the war has brought upon the country.

With the arrival of the refugees serious complications arose for the

Russian village. In the first place, the unfortunates received a pension from the government, which was sufficient to provide them with the bare necessities of life. Such being the case, they were by no means inclined to exert themselves in the fields. Secondly, the majority of them were women and children. The Russian *baba,* as we have described above, can work in the fields as well as a man. This is not the case with the inhabitants of Poland and Lithuania. If extra hands are needed there in the fields they are hired. The women occupy themselves at household tasks or peasant industries—weaving, embroidery and the like. Thus the intention of the government, which had aimed at utilizing immigrants to help out the situation, was baffled, and the expected benefits did not materialize. The arrival of the refugees, apart from the above, had one serious economic consequence, which was felt most oppressively by the peasants themselves. The payment of the subsidies by the government to the refugees brought a considerable amount of ready money into the outlying villages. This caused a sharp rise in prices on food, the burden of which fell upon the peasants. The result was a widespread dissatisfaction, and to the same the government was forced to devote its most serious attention.

When we take it all in all, it seems to the writer that the Russian village has withstood the test of war conditions remarkably well. Part of the credit for this is due, no doubt, to the communistic basis of the land ownership (the *mir*). This has enabled the peasants to distribute their burdens more equitably, and has maintained a higher productive level. This is the more remarkable, when we remember the low percentage of literacy which prevails in Russia. One hears very often that the Russian peasant knows but little about the war. This is to a certain extent correct, for news penetrates slowly to the outlying hamlets. He is vitally interested in the war, however; there is hardly a family throughout the empire which has not one or more of its members in the field. No matter how ignorant your peasant or your *baba* may be, the fate of their nearest and dearest is a matter of vital import, and such news as penetrates is assimilated and comprehended—though perhaps partially and incorrectly—by each recipient according to his or her mental development.

Should it then come about, as all true Russians believe and hope it shall, that the Germans will be defeated, the glory will not be the guerdon of the valiant peasant alone, who has dyed with his blood the treacherous swamps of Poland and the rugged passes of Armenia, but an equal share must likewise be given to his patient and hard-working wife and mother, who cultivated the fields and cared for the children behind the bulwark reared by their husbands and fathers.

FLORA OF THE VICINITY OF NEW YORK

Y NORMAN TAYLOR

BROOKLYN BOTANIC GARDEN

IN 1749–1751 Cadwallader Colden, lieutenant-governor of New York and correspondent of Linnæus, published the first flora of New York and vicinity. It was a list of the plants as observed by himself and his daughter Jane Colden, growing near their home in what is still called "Coldenham," Orange Co. Written by a man who wrote to Gronovius that "botany is an amusement which may be made greater to the Ladies who are often at a loss to fill up their time," it well reflects the attitude of his period. As a historical record the list is valuable. As a forecast of the modern position of botany or women, his remarks are commended to botanists and to those feminists who find it difficult to "fill up their time."

Not until 1819 was there another list of this importance, when John Torrey published his "Catalogue of Plants growing Spontaneously within thirty miles of the City of New York." This was a book of 102 pages and listed hundreds of species and varieties, some of which are now rare or extinct near the city. To touch only the high spots of a long historical record, mention should be made of Leggett's "Revised catalogue of the plants, native and naturalized, within thirty-three miles of New York" (1870–1874) and the "Preliminary Catalogue of Anthophyta and Pteridophyta" reported as growing spontaneously within one hundred miles of New York City by Britton, Stearns and Poggenburg (1888). Some of these lists contained notes on the distribution of the species, but in most cases only lists of plant names were possible. The outstanding character of them all, as in the beginnings of most science, was that they were chiefly records of facts. They were the culmination of our forefathers' study of the local flora, arranged in orderly fashion, which at that time was all that could be done.

It is impossible to talk about the vegetation of New York without knowing very definitely what are the units of that vegetation, and it is the chief legacy of this older generation of New York botanists, that they have handed down to us so complete and so accurate a record of those units, as they knew them. There were, of course, hosts of minor efforts covering the region near the city, or parts of it, about which nothing can be said here, except that like the more important works their object was simply to record the facts. It should not, however, be implied that these workers lacked a larger vision which should seek to explain or correlate their patiently acquired facts. For we find in July, 1870, a forecast of what they were striving for, when in

the *Bulletin* of the Torrey Botanical Club there appeared in an account of the floral regions of that area, the statement that

> Any rational catalogue of our flora should distinguish what plants are absent from or peculiar to each natural region and should contain such information in reference to soil, climate, etc., as may help to elucidate the distribution.

Among purely local botanists, this was, I think, the first statement implying causation that had appeared. Gray, Torrey and Hooker had all written extensively of the flora of North America, and some of them, at any rate, had written on the larger problems of the origin and distribution of the North American flora. For the region about New York, with its variety of conditions, there seems to have been no opportunity until quite recently to attempt to fulfil the hope of the writer in 1870 who is quoted above.

Recent studies of the flora show that there are about 2,600 different species of flowering plants and ferns known to grow within, roughly, 100 miles of the City. Of these 85 are ferns and their allies, 23 are conifers and the balance is made up of our ordinary flowering plants. Of the total flora some 613 species have been introduced from outside the area, by man or otherwise, leaving slightly more than 2,000 species of native plants in the region within one hundred miles of the City.[1]

It is a matter of common observation that these plants are not generally distributed throughout the region. In traveling from the Catskills to Cape May, the northern and southern limits of the area studied, we see a variety of plants found in one or the other of these widely separated localities, but not in both of them. Many species find their outposts of distribution near New York. Some appear to have come from the North or South, a few from the West, others are apparently endemic in the area, and this great quantity of forms, the apparent chaos of it all, raises many questions. What is the real composition of our flora, whence derived, and above all how did it reach its present luxuriance and beauty? The attempt to answer these questions necessitates a review of the causes that have influenced the origin and distribution of our native flora.

For all practical purposes the agencies affecting the distribution of our native plants may be divided into edaphic and climatic ones. Under the first must be considered all questions of the relation of the vegetation to the soil and available water supply; or more simply stated the geological factors of distribution; under the second the relation of the flora to climate must be the chief concern.

From the point of view of plant distribution the last geological phenomenon is the most important, as the continental glacier the fringe of which stretched through Long Island, Staten Island, northern New Jersey and Pennsylvania, had a profound influence on the migration

[1] *Mem. N. Y. Botanical Garden*, 5, 1–683, 1915.

of the flora existing at that time. It is obvious that whatever the effects of geological eras before the ice age may have been on the then existing flora, this great ice sheet must have obliterated all the vegetation in the region which it covered. All the region north of the southern edge of the continental ice sheet must have started with vegetatively a clean slate, as it were, when the ice receded. What was the edge of the ice sheet is now marked by an irregular range of hills which stretch from Montauk Point to northeastern Pennsylvania. These morainal hills mark the present southerly distribution of many of our species of plants. Over 8 per cent. of our native flora has never been found south of these morainal hills, notably the red pine (*Pinus resinosa*), the balsam (*Abies balsamea*), yellow birch (*Betula lutea*) and *Quercus borealis* among the trees; *Ribes glandulosum,* the shrubby cinquefoil (*Dasiphora fruticosa*), many thorns, the *Rhodora* and *Kalmia glauca* among the shrubs, besides scores of herbaceous plants.

This glaciated part of the range is characterized, too, by the large percentage of hardwood deciduous trees, and by the great number of introduced plants that are found there. Most of our European weeds flourish in the much-cultivated region north of the moraine.

The unglaciated part of the area is mostly occupied by the coastal plain which, on the whole, is characterized by the long sandy or gravelly stretches that are found on southern Long Island and New Jersey. All of the region is geologically the most recent in the area, the surface being largely made up of Tertiary and Cretaceous deposits in New Jersey and over-wash material from the glacier on Long Island. From the standpoint of the botanist the chief thing of interest about the coastal plain is the pine-barren region of New Jersey. This region is so unusual that the ordinary traveler is at once struck with the difference between these sandy stretches of pine-tree vegetation and the richer flora further north.

It has been shown[2] that the pine-barrens occupy almost exclusively the Beacon Hill formation, in New Jersey, which has been uninterruptedly out of the water since upper Miocene time, and has been several times partly, or wholly, surrounded by sea water. Because of its continual emergence it is the oldest region in our area that can have been continuously covered with vegetation. For the region surrounding the barrens was subject several times to the invasion of sea water, and as we have seen the glaciated area, geologically much more ancient, must have been fairly scraped clear of vegetation by the ice. In other words, the New Jersey pine-barrens exist exclusively on the Beacon Hill formation, an area isolated by geological processes and maintaining a relict flora, which is much older in permanency of occupation than any of the rest of the flora near New York.

Ancestrally our local flora must have consisted of purely American

[2] *Torreya*, 12, 229–242, 1912.

plants, many of which were of southern affinities. Many southern species still reach their extreme northern outposts of distribution in this region. Most of the southern species are found on the coastal plain, but a few have spread north and west of it. At the present time over 13 per cent. of our local plants reach their northern limits within one hundred miles of the City of New York. Many other southern plants, also, range only slightly to the north of us.

About 8 per cent. of the native vegetation, also, consists of northern species that reach their southern limits within the local flora area, and many more are found to the south of us in the mountains. The great range of hills, stretching northeast-southwest from the Berkshires through the Catskills and the Highlands of the Hudson in New York, the Kittatinny in New Jersey and to the Blue Mountains of eastern Pennsylvania, serve literally as a broad highway down which a host of northern species are scattered, and to the seaward of which certain kinds have never been known to go. That other great group of species that creeps, almost insidiously, from the south, seems perforce to have been huddled between the mountains and the sea. The transition between these northern and southern elements of our flora is, of course, nothing like so sharp as the geological regions they generally occupy would seem to indicate. Many sporadic marauders have spread from both camps, apparently far out of their element. Sometimes these lonely outposts survive the competition of the new environment; that is notably the case of the hemlock in southern New Jersey, far from its usual rocky hillsides, and of the coast white-cedar (*Chamæcyparis*) which flourishes in the coastal-plain bogs, and maintains a rather splendid isolation at Greenwood Lake, in northern New Jersey. Scores of these cases could be cited illustrating the main lines of the distribution of our flora by occasional aggressive exceptions to it. Such sporadic occurrences form one of the most fascinating chapters in the history of our native flora, for are they not militant outposts of a mighty horde of conservatives? Sometimes they perish miserably as the little twin-flower has long since done on southern Long Island, miles from its mountain home. Of the number of such tragedies no man can even guess, still less speculate as to their causes, but speculation could weave about such occurrences, and they are very numerous even in such a limited area as this, a story the significance of which has breath-taking possibilities. For with these outcasts, whether living or dead, is bound up a whole history of changing climates and shifting levels of our continent—mighty forces which have scattered here and there mute little relics of their sport.

The real potency of these geological forces, or historical factors of distribution, is so great and its appeal to the imagination can be made so alluring, that we are in danger of attributing the general complexion of our vegetation almost solely to them. Nothing could give us such a

one-sided, wholly erroneous conception. Our present climate, particularly temperature, seems quite certainly to be the controlling factor in the present distribution of many of our native species. As to rainfall and the winds, their variation seems almost negligible in so small a region, but temperature is a much more serious matter. There seems to be a rather well-defined temperature barrier through which some plants have never been known to go.

For a variety of reasons that need not detain us here, the particular criterion of temperature response that has been studied in connection with our native flora is that of the length of the growing season. This is determined by figuring the number of frostless days in different parts of the area. The accompanying map illustrates the method better than a page of explanation could do. The arbitrarily drawn black line through the map indicates the dividing line between colder and warmer regions of our area. It marks, with occasional exceptions, the southerly limit in our area of many cold-country plants. North of it occur most of our higher elevations where the mountain species are found. The difference of three months in the growing season as between the Catskills and Cape May is very nearly as impressive as the conspicuously different vegetation of these widely separated localities.

The mental convenience of considering separately the effects of

FIG. 1. MAP ILLUSTRATING THE LENGTH OF THE GROWING SEASON WITHIN 100 MILES OF NEW YORK. The figures represent the number of days between the last killing frost in spring and the first of autumn. The dark line separates the warmer from the colder parts of the area, and indicates generally speaking a climatic barrier through which certain of our native plants have never been known to go.

geology and climate on the distribution of our flora must not blind us to the fact that these agencies do not work independently. The interaction of these, the further complication of the personal "aggressiveness" of certain species, if that term can be applied to plants, and many other minor factors, make the problem most complex. In any particular case it may be practically impossible to say whether a given plant exhibits response to climatic or geological factors, or to both, least of all as to what possible combination of both. All that can be done is to set down the facts of distribution, both with relation to geology and to climate, and to estimate the relative proportion of the potency of each. That such a study must spell a large measure of failure should deter no one. For by it is acquired an outlook upon the vegetation of an area that no preparation of lists of species can possibly confer. Upon such a conception a flora ceases to be a catalogue, mere scaffolding for the structure that is to follow, as necessary and as uninteresting as the telephone directory. Upon such a conception a flora need not concern itself with the latest hair-splitting refinements of the ever-present species-monger. All of these things are subsidiary to the larger problems that come from what may be called a causative study of a flora. By it each of our native plants takes on an added interest, to many there may be attached a history that fascinates the most unimaginative, to the whole is given a new impetus and a broader vision, which can make of any landscape something very like a dramatic spectacle.

Troublesome persons with a practical bent will want to know of what use such a study of any flora can be, least of all of the region near New York. Apart from its consideration as a great out-door experiment or laboratory where all sorts of principles of distribution can be studied at first hand, there are purely local problems that are commercially important. The draining and reclamation of our great salt-marsh areas on Long Island and in New Jersey, which is bound up with mosquito extermination, offers an attractive field of work where such knowledge will have a direct bearing. The profitable utilization of the southern part of Long Island, now a dreary waste of scrub-oak and pitch-pine, and of the pine-barrens of New Jersey, must involve the utilization of such studies to insure a full measure of success. The timber and crop possibilities of some parts of the area are well indicated by the wild vegetation, and the vegetational history of many parts of the region must serve as a clue to its most profitable future utilization. Thus a study of a flora from the standpoint of its fitness for its environment, and the intimately related study of the environment as fitted to the existing flora, must bulk large in any rational scheme for the agricultural or horticultural development of the region near the city, many parts of which are still wholly undeveloped, or, worse still, have been recklessly exploited.

TWO HISTORIC WORLD-PESTILENCES ROBBED OF THEIR TERRORS BY MODERN SANITATION

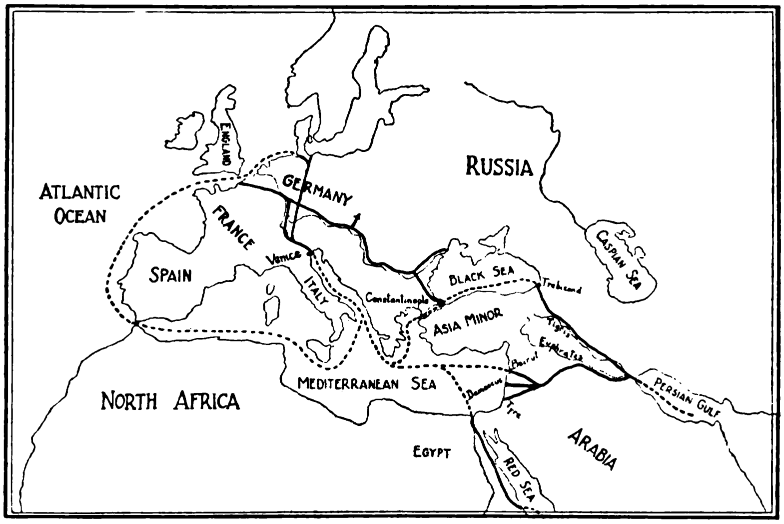
D. GREENBERG

DEPARTMENT OF PUBLIC HEALTH, AMERICAN MUSEUM OF NATURAL HISTORY

THE presence of bubonic plague at New Orleans two years ago and the recent outbreaks of cholera which have followed upon the progress of the war in Austria are striking reminders of two of the most terrible pestilences which have ever scourged the human race. They are of special interest to the student of history and geography because in the past these two diseases furnished admirable examples of the manner in which infection travels along trade routes in the wake of commerce and migration. The security which civilized countries may enjoy against their attacks is a brilliant demonstration of the triumphs of modern sanitary science.

Bubonic plague, the Black Death of the Middle Ages, with which our National Health Service has successfully grappled at New Orleans, is one of the most virulent diseases known to sanitarians and if not immediately recognized and attacked would claim victims without number. From time immemorial we have records of the presence of this pestilence. The Levant and adjoining countries have been the centers of plague for at least 3,000 years, due to their unique positions as the gateway between the East and the West. Biblical reference to this disease as occurring among the Philistines is found in the Book of Samuel (I Samuel, Chaps. V. and VI.). The world has passed through two worldwide epidemics of plague in the past and we are now in the midst of a third.

The first authentic epidemic of plague originated at Pelusium in Egypt, in 542 A.D. At that time Pelusium was a leading center for trade between the East and the West. By means of travelers and merchants the disease spread slowly through Alexandria and the rest of Egypt, on the one hand, and, on the other, passed into Palestine and over the then known world, following closely the highways of commerce. In order to trace more clearly the connection between commerce and the spread of the plague, it is well to remember that the main routes between Europe and the East were along the Mediterranean Sea and overland through Turkey, Germany and France. It was along precisely these routes that plague traveled, as can be seen from the accompanying maps. At the height of the epidemic the number of dead reached 5,000 a day and during some days the mortality rose to 10,000. According to Procopius, a witness of this epidemic,



TRADE ROUTES DURING THE MIDDLE AGES
FIG. 1.

it spared neither island nor cave nor mountain top where man dwelt. . . . Many houses were left empty and it came to pass that many from want of relatives and servants lay unburied for several days. At that time it was hard to find any one at business in Byzantium. Most people who met in the streets were bearing a corpse. All business had ceased, all craftsmen deserted their crafts. . . .

The second great epidemic of plague, known in history as the Black Death, originated in Mesopotamia, an old endemic center of this disease, about the middle of the eleventh century. It is thought that the returning Crusaders during the twelfth and thirteenth centuries assisted in this recrudescence of plague. Again the disease followed the routes of travel and commerce, but this time going further north into Europe. During this epidemic some 25,000,000 people, or one fourth of the population of Europe, are said to have perished. It was a veritable Black Death, for the degradation and misery which Europe suffered during the Middle Ages and from which it very slowly recovered, was largely due to this pestilential disease. Towns were left empty and all trade was at an end. All feared "the pestilence that walketh in darkness," none knowing when their turn would come to be smitten.

Venice at this time was the gateway through which the commerce of the East passed into Europe. Goods were brought by caravans to the shores of the Mediterranean or the Black Sea and from these points carried by ships to Italy to be distributed over Europe. On their way to the Mediterranean the caravans passed through the endemic centers of plague in Asia Minor, bringing the disease to all regions through which they passed.

The close parallelism between commercial routes and the spread of

FIG. 2. ORIGIN OF FIRST EPIDEMIC OF BUBONIC PLAGUE IN PELUSIUM, EGYPT, 542 A.D. (indicated by dot).

plague is illustrated by the fact that with the discovery of a new route to India by way of Cape of Good Hope the plague almost entirely disappeared from Europe. Just as a single rock may alter the course of a stream, so the discovery of this new route brought about the abandonment of the Mediterranean as a highway of commerce in favor of the water route by way of the Cape. As a result the seaports of northern Europe came into prominence as commercial centers whose connections with the East by way of the sea enabled them to avoid the old endemic centers of Asia Minor, and from this time on plague gradually disappeared from Europe.

The present epidemic, the third in the world's history, had its origin in the town of Junnan Fu in China in 1871. The disease spread to neighboring towns and reached Hongkong in 1894. From this point it traveled to India where it raged unchecked for more than ten years, carrying off 6,000,000 of the natives. Since its appearance in India in 1894, the plague has visited many of the larger seaports all over the world, the infection coming either from China or from India. In nearly every case the disease made its first appearance at a seaport, but in some cases, as at Johannesburg and Mecca, it was carried into the

FIG. 3. PROGRESS OF FIRST EPIDEMIC OF BUBONIC PLAGUE 544-570 A.D. (indicated by heavy shading).

interior by the hordes of gold seekers and pilgrims who flocked thither from infected areas.

Very few people realize that at the present time we are in the midst of a potentially serious pandemic and that only the constant vigilance of our authorities enables us to avert such epidemics as culminated in the Black Death of the fourteenth century. Beside the severe outbreaks in Manchuria and India, the present plague has manifested its presence in all of the principal Chinese seaports, traveling from its source of origin east to Melbourne, Brisbane and other Australian cities, south to Portugal and Scotland, and around the world to Brazil, Porto Rico and California. Yet in spite of this almost universal diffusion, our knowledge of the rat as the carrier of the germ of plague has made it possible to confine the disease within narrow limits everywhere outside of Asia.

From time immemorial various explanations have been given of the causes of plague. From Biblical records, we learn that this pestilence was considered a judgment which God in his wrath inflicts upon man to punish him for his sins. The connection between human plague and the disease among rodents was long ago suspected, for mention is made in the Book of Samuel of the fact that in order to stay the progress

FIG. 4. MAXIMUM EXTENSION OF FIRST EPIDEMIC OF BUBONIC PLAGUE 570–650 A.D. The disease spread to all the then known parts of the world (indicated by heavy shading).

of the disease offerings were made of golden images of mice and of the tumors characteristic of plague. Others have looked upon the disease as an emanation from contaminated soil, while others have blamed the air as the carrier of this pestilence.

Plague as we know it to-day is primarily a disease of the rat and only secondarily a disease of man. The germs of the disease are transmitted from rat to rat and from rat to man through the agency of the flea. When a rat dies of plague the fleas leave the dead animal and by preference attach themselves to other rats, attacking human beings only if there are no other rats to be found. The fleas which carry the germ of bubonic plague fasten themselves upon rats, from the blood of which they take their nourishment. Thus Jonathan Swift's jest about the endless chain of parasites which prey one upon the other, finds here an apt illustration of its scientific truth.

Modern sanitary science recognizes two steps in the solution of the plague problem—first the keeping out of plague cases by strict quarantine measures and second the elimination of the carrier, namely, the rat.

The latter solution is not as easy as one might at first suppose, for even on the best guarded ships and trains rats somehow find their way

FIG. 5. ORIGIN OF SECOND EPIDEMIC OF BUBONIC PLAGUE IN MESOPOTAMIA IN 1050 (indicated by dot).

aboard and take passage as stowaways. Having reached a new port they commence breeding very rapidly and before long have established a firm footing in their new environment. If we could successfully control the peregrinations of the rat the spread of plague would be easily checked, but this being impossible we must wage a war of extermination against him. This may be done either by killing the rats or by destroying their breeding places. The common methods of exterminating these rodents are by trapping, by poisoning, and by utilizing the rats' natural enemies. Traps and poisons have been used with some measure of success, but the rat by his constant association with man has become extremely wary. Rats have been known to enter traps, stand upon the pan with their hind legs, eat the bait and then carefully turn around and back out. They will eat the bread on which poison is spread so carefully that practically all the bread will be eaten while the poison will be left behind. The rats' natural enemies—the cat, dog, weasel and skunk—when given a fair chance will quickly drive him out. The war on rats carried on at San Francisco in 1907, at the time of the appearance of plague in that city, proved the great value of cats and dogs, and to-day San Francisco has a law requiring all structures of

FIG. 6. PROGRESS OF SECOND EPIDEMIC OF BUBONIC PLAGUE 1100-1300. This time the disease spread to the East as trade routes became extended.

800 square feet or less, within certain districts, to be raised high enough above the ground to allow these animals free access to the under side of the building.

Such methods will remove a considerable proportion of the rats, but it is only by prevention of their further breeding that we may hope satisfactorily to control their numbers. The rat requires two conditions for life—plentiful food and a place for nesting. Eliminate either of these and the problem of extermination is solved. To prevent the rat from getting sustenance all places where food-stuffs are stored, such as packing houses, bakeries, groceries, warehouses, grain sheds, docks and wharves, should be either rat-proofed or should contain rat-proof receptacles for the food. Particular attention should also be paid to the proper disposition of garbage. To prevent the rat from entering buildings and nesting among the beams underneath the floor, the latter as well as the foundation walls should be concreted and all openings in the basement screened.

The rats which are most dangerous are of course those brought from plague-ridden countries. To prevent such rats from landing recourse is had to the fumigation of ships and the using of rat guards—

FIG. 7. MAXIMUM EXTENSION OF SECOND EPIDEMIC OF BUBONIC PLAGUE, 1200–1450. The close parallelism between trade routes and the spread of the disease is indicated by comparing with Fig. 1.

which are nothing more than circular sheets of metal about two feet in diameter fastened in a vertical position on the ship's mooring lines. By preventing the plague rat from taking passage and from landing we can control the diffusion of plague to other ports; for we know that where trade will go there rats will go and where rats will go there plague will go. Our slogan should therefore be "No rats, no plague."

The other solution of the plague problem which consists in the quarantining of all cases of this disease, derives its name from the practise of the Venetians during the Middle Ages requiring the detention for forty days of all persons well or sick coming from an infected port. To-day, however, with our increased knowledge of sanitary science, preventive measures have become more efficient and less irksome. Ships coming from infected ports are detained for but a day, during which time the infected passengers are isolated, and the vessel fumigated. Isolation of individuals takes the place of quarantine against nations.

The plague very recently discovered at New Orleans would have brought consternation a decade ago, but to-day with the efficient protection of our ports no fear is entertained. Our knowledge of the rat as the carrier of the germ of plague has made it possible to keep this

FIG. 8. ORIGIN OF THIRD EPIDEMIC OF BUBONIC PLAGUE IN JUNNAN FU, CHINA, 1871 (indicated by dot).

disease from spreading, to any considerable extent, anywhere outside of Asia. By enforcing quarantine laws, by disinfecting all ships suspected of harboring infected rats, by preventing the rat from landing, and by the comparative freedom of civilized cities from vermin, we have been able to keep plague from extending beyond the ports at which it has sporadically appeared. It is due to a thorough knowledge of these facts and to the careful sanitary precautions based on this knowledge, that we are not at present suffering from a Black Death similar to the one that ravaged and devastated Europe and Asia in the fourteenth century.

Another of the most dreadful diseases of medieval times is Asiatic cholera. Although this disease was described as early as the fourth century, yet no record appears of its occurrence in epidemic form until the sixteenth century. During the sixteenth, seventeenth and eighteenth centuries cholera was epidemic at various times in India. The disease is indigenous to that country and has been disseminated from India to all quarters of the globe. It is one of the most serious of scourges of unhappy India, the average annual mortality from cholera for the years 1898 to 1907 in India being 366,378.

FIG. 9. PROGRESS OF THIRD EPIDEMIC OF BUBONIC PLAGUE, 1874-1894.

With the increase of commercial intercourse between nations in the nineteenth century, cholera began to spread rapidly and usually, as in the case of plague, along the routes of trade and travel. It was not until 1817 that European physicians were attracted to the study of the disease by an outbreak of a violent epidemic at Jessore in Bengal. This epidemic extended westward from India along two routes—(1) by sea to the shores of the Red Sea, Egypt and the Mediterranean; (2) by land to northern India and Afghanistan, thence to Persia and Central Asia and so to Russia. The disease ravaged the northern and central parts of Europe, spread to England and subsequently appeared in France, Spain and Italy. Then crossing the Atlantic it made its appearance in North and Central America.

Four serious epidemics or pandemics of cholera have occurred, one from 1817–1823, another from 1826–1837, a third from 1846–1862, and a fourth from 1864–1875. In 1832 the disease appeared in New York and extended as far west as the military posts of the upper Mississippi. Later in 1848 it entered the United States through New Orleans, passed up the Mississippi and was carried across the continent by the searchers for gold on the way to California. Immigrant ships brought cholera to our shores again in 1857 and in 1892 and in the latter year only

FIG. 10. MAXIMUM EXTENSION OF THIRD EPIDEMIC OF BUBONIC PLAGUE, 1894. This time the spread of the disease is limited to Asia and occasionally to a seaport.

aggressive measures at New York prevented its spread to other points. The fear of cholera was the most successful lobbyist in favor of the creation of the New York city board of health during the epidemic of 1865–1866, and without whose aid the board would scarcely have succeeded in obtaining the needed powers and the required funds for efficient health measures.

While the home of cholera is in the tropics, there is scarcely a country in the world that has not been visited at one time or another by the ravages of this scourge. To-day, however, the disease is largely limited to tropical countries where insanitary conditions still exist.

Like bubonic plague, cholera is spread by man from place to place and this follows the lines of trade and travel. Pilgrimages and fairs are a great factor in the dissemination of the disease, favored by the overcrowding and insanitary conditions usually existing at such gatherings. The dispersal of such gatherings then disseminates the disease over wide areas. One of the most important of these recurrent festivals is held at Jaganath temple at Puri in the province of Bengal. Upwards of 100,000 pilgrims gather at this place during July when the principal festival is held. Endemic cholera is rarely absent in Puri and out-

Courtesy of Louisiana State Board of Health.

FIG. 11. SAFEGUARDING A PIER AGAINST RATS. By means of the rat guards on the hawsers and by fenders, rats are prevented from landing.

breaks almost invariably occur at the time of these gatherings—in 1899, 1,216 cases with 1,020 deaths occurred at the July festival in Puri alone.

Cholera, however, spreads along avenues not common to plague. One of the most important of the vehicles of this disease is water. Numberless epidemics have been traced to the pollution of a water supply by a cholera patient. A notable classic example is the Hamburg epidemic of 1892. Cholera was brought to Hamburg by immigrants either from Russia or France. The waters of the Elbe River receiving the wastes of the city were infected with the discharges of the cholera patients, and this water was used by the inhabitants without previous purification. The water supply of Altona adjoining Hamburg was taken from the same river, but first subjected to sand filtration. An outbreak of cholera ensued in Hamburg with 16,957 cases and 8,606 deaths, while 516 cases and 316 deaths occurred in Altona, most of the cases occurring in Altona being traced directly to infection in Hamburg.

Reports from European battlefields inform us of the presence of cholera in Austria. This scourge has been responsible for deaths without number in the wars of the past, for war, famine and pestilence go hand in hand. No army can be considered safe if once it should appear in the theater of operations unless the most stringent precautions against its extension are taken.

In the Crimean war during the months of July and August of 1853, cholera lost to the French army before a shot had been fired as many men as were killed by the enemy during the entire campaign and siege. The number of cases totalled 12,258 and deaths 6,013. The British in this war lost 11,097 men from disease and of this number one fourth died of cholera.

During the war between Austria and Prussia in 1866, the latter country lost more men from cholera than from the casualties of battle.

In our own Civil War upwards of 3,400 cases and 1,500 deaths resulted from the ravages of cholera. This scourge almost destroyed an entire body of recruits brought from New York.

During the war between China and Japan in 1894–1895, cholera claimed 9,658 cases with 5,991 deaths, out of a total of 15,860 deaths from disease, from a mean strength of 227,600.

To-day we know that disease germs are stronger and more deadly than bullets, so that the soldier is sent forth prepared to meet cholera or other scourges that attack men in the field. The soldier is protected against typhoid and cholera by vaccination against these diseases, by attention to the sanitary conditions of the camp, by sterilizing the water supply, by protecting food from flies, by caring for the wastes and by isolation of cases of such communicable diseases. That such precautions can be maintained under the stress of a great war has already been demonstrated.

It is certain, however, that in times of peace cholera, like plague, has no longer any terrors for modern civilization. In the summer of 1911, ship after ship came into the harbor of New York from cholera-infected ports. They were detained for no long period of quarantine; but in 24 to 48 hours every passenger was subject to examination and the carriers of the deadly "comma bacillus" were picked out and isolated. The examination of 26,930 persons at the port of New York revealed 27 such carriers. The rest of the passengers were sent on their way, and the pestilence which used to pass in great waves from continent to continent found an impassable barrier placed in its path by the culture tube and the microscope of the bacteriologist.

THE PROGRESS OF SCIENCE

WORK OF THE NATIONAL RESEARCH COUNCIL

At the recent meeting of the National Academy of Sciences in Washington, one of the sessions was devoted to the work of the National Research Council. Dr. George E. Hale, of the Mt. Wilson Solar Observatory, chairman of the council, presided, and reports were made by the following chairmen: Dr. Charles D. Walcott, secretary of the Smithsonian, for the military committee; Dr. Robert A. Millikan, of the University of Chicago, for the physics committee; Dr. Marston T. Bogert, of Columbia, for the chemistry committee; and Dr. Victor C. Vaughan, director of the Medical Research Laboratory, University of Michigan, for the medicine and hygiene committee.

In connection with the work accomplished by the military committee, Dr. Walcott, who is also a member of the National Advisory Committee for Aeronautics, stated that investigations had been conducted with noxious gases as employed for military purposes; problems connected with all forms of signalling had been studied; the utilization of opium for obtaining a supply of morphine for medical purposes had been considered, and improvements had been suggested in the service army blanket, which is not thought to be warm enough. Other work for military establishments of the government is confidential.

In reporting for the committee on physics, Dr. R. A. Millikan stated that they were cooperating with the American Physical Society and the American Association for the Advancement of Science in an effort to find the men and the means for attacking certain physical problems which are now confronting the national government. While no information as to the exact nature of these researches was given out, the chairman stated that four or five of them were submarine problems, several pertained to aeronautics, and some were optical, having to do with range-finding devices and the production and use of optical glass. Experiments with the X-ray are being conducted for the government, as are studies in thermal conductivity, atmospheric electricity, as encountered by airships, and even the manufacture of guns. The study of these problems has brought to life the vital need of a central coordinating body, such as the council. For example, certain questions concerning the submarine were being considered separately by a naval investigating board, three of the industrial research laboratories, and a number of universities before the solution of its various phases are undertaken and distributed by the council. Encouraging results have been secured as the committee has become familiar with the general lines of attack of each investigation.

At the request of the Council of National Defense, the National Research Council has entered into close relations with it, acting as one of its departments. It is, in this capacity, charged with the organization of scientific research so as most effectively to contribute to national defense directly, and to the support and development of those industries affected by the war. In order to carry out this scheme of cooperation the Research Council and several of its subcommittees have secured offices in the Munsey Building, Washington, D. C., where also are the headquarters of the Defense Council. The Research Council as a whole is represented by its chairman, Dr. George E. Hale, and by Dr. R. A. Millikan, the vice-chairman, charged with the correlation of research problems in general. The subcommittees are represented in Washington as follows: Military: Dr. C. D. Walcott, chairman; Dr. S. W. Stratton, secretary, and other

WILHELM VON WALDEYER

The distinguished anatomist of the University of Berlin who has been made a hereditary noble on the occasion of his eightieth birthday. The photograph was taken at the St. Louis Exposition.

members representing various departments of the government; Physics: Dr. R. A. Millikan, Dr. C. E. Mendenhall; Chemistry: Dr. Marston T. Bogert, Dr. A. A. Noyes; Medicine and Hygiene: Dr. Victor C. Vaughan; Engineering: Dr. W. F. Durand.

As rapidly as possible these representatives are getting into touch with defense research problems through the military branches of the government, in which matter the military committee plays an important part, at the same time bringing these problems to the attention of the research men and organizations. The representatives in Washington will, among other things, act as a central clearing house for the reception of problems from the government, and their proper distribution; will sift, distribute and follow up suggestions of a scientific or engineering nature received from any source, individuals or groups; and will keep those who are working on specific problems informed as to the progress being made by others working along the same lines. It is the desire of the Research Council to do anything possible to stimulate scientific activity and aid in any possible way its direction and concentration upon the most vital and immediate problems.

INLAND FISH AND GAME AS FOOD SUPPLY

According to a statement issued by The New York State College of Forestry at Syracuse University, the fish and game which can be produced from lakes and non-agricultural areas within New York State will go a long way toward augmenting the meat supply. Acting Dean F. F. Moon has appeared before the Governor's Patriotic Agricultural Commission and made a number of specific suggestions concerning the increase in the production and use of fish from inland lakes, and game which could be raised on lands unsuited to tillage throughout New York State. Dr. Charles C. Adams, at the zoology department at the College of Forestry is authority for the statement that 100 tons of eels are caught each year in Oneida Lake, and that press notices last fall tell of the capture by game wardens of several trap nets illegally set in this lake from which about thirty tons of fish were set free. Acting Dean Moon suggests: That seining of inland lakes and streams by state officials for mature food fish be permitted during the period of the war. The taking of these fish should not be allowed during the breeding season, and the possession of seines by any person, except state officials, should be made illegal. All suitable food fish in inland waters should be used under this plan without exterminating any species.

Federal and state hatcheries in New York are already turning out large numbers of fry, but when liberated a great many of these are destroyed by natural enemies. Fish nurseries can be built cheaply and quickly, and will turn out great quantities of fish which would soon reach market size. Federal or state employees, who are often released from hatcheries during the summer, could be utilized to take charge of one or a group of these nurseries.

Carp breeds prolifically, matures rapidly and is capable of furnishing a tremendous amount of protein food. At present this fish is found on the markets of thirty-five states, and about 20,000,000 pounds are sold annually. The disfavor with which many consider carp should not belittle its value as food under war conditions.

As a result of conservative game regulations in Germany, venison can ordinarily be bought during any season, and is now more plentiful than beef, butter or eggs. There is no reason, in spite of possible opposition from certain types of sportsmen, why a substantial reserve meat supply should not be created by this provision. Game farms now owned by the state might be turned primarily into food-producing establishments. The equipment used for turning out pheasants and other fowls could be used for

JOSEPH HENRY

Model of a statue by John Flanagan now in State Museum at Albany, N. Y. When cast in bronze it is to be erected in the park facing the Albany Academy, where Henry conducted his experiments on electromagnetism.

hatching and rearing ducks or other poultry which would mature rapidly. Belgian hares could also be raised and all the animals produced would be available for use at state institutions or for distribution at cost for breeding purposes in order to stimulate private food production.

The possible utilization is suggested of cutover state forest lands for grazing purposes under strict supervision, sheep, for instance, could be fattened on this wild land, either publicly or privately owned. The Federal Forest Service received during the year 1916, $1,210,000 from grazing fees, and two years ago the chief forester reported that one sixth of the total meat supply of the nation came from animals grazed, for a portion of the year at least, within the boundaries of the national forests. All these suggestions, according to Acting Dean Moon, are in accordance with the belief that the college has maintained during its organization that the freest use should be made of all waters and non-agricultural land for the production of the necessities of life.

WELFARE WORK IN BRITISH MUNITION FACTORIES

THE efforts being made in Great Britain to conserve the health of munition workers through systematic and carefully planned welfare supervision in factories and workshops are described in a bulletin issued by the Bureau of Labor Statistics of the U. S. Department of Labor. This bulletin, the second one in the group reproducing documents giving foreign experience in dealing with labor conditions growing out of the war, includes reprints of the memoranda published by the British Health of Munition Workers Committee covering the subjects of welfare supervision, industrial canteens, canteen construction and equipment, investigations as to workers' food and suggestions as to dietary, and washing facilities and baths. The bulletin also includes an article on "The value of welfare supervision to the employer," by B. Seebohm Rowntree, a manufacturer, and director of the welfare department, British Ministry of Munitions.

The home secretary has been given powers to secure the welfare of munition workers by issuing orders, regulating such matters as arrangements for preparing or heating and taking meals, supply of drinking water and protective clothing, ambulance and first-aid provision, supply and use of seats in workrooms, facilities for washing, accommodation for clothing, and supervision of workers. No contribution may be exacted from workers for these benefits, but for additional benefits which the employers may not reasonably be expected to provide, an assessment may be made if two thirds of the workers assent, in which event the workers are permitted to have representation in the management of the arrangements, accommodation or other facilities to be provided.

It appears from the welfare memoranda that industrial efficiency depends largely upon consideration of the health of munition workers through proper attention to such questions as housing, transit, canteen provision and individual welfare of the employee, which have become of vital concern to manufacturers who appreciate the necessity of conserving their labor force in order to attain a maximum of production in the shortest space of time. Managers generally testify to the value of the services rendered by welfare supervisors. The committee recommends as particularly important the appointment of a competent woman welfare supervisor of experience and sympathy who shall devote her attention exclusively to problems affecting the health of women and girls, to the character and behavior of fellow women workers, to the maintenance of suitable and sufficient sanitary accommodations, to the capacity of workers to withstand the physical strain and stress of work, and to their power to endure long hours, overtime and nightwork.

Closely allied to welfare supervision as noted is the necessity for adequate provision of canteen facilities where workers may obtain a dietary containing a sufficient proportion and quantity of nutritive material, sufficiently varied, easily digestible, and at a reasonable cost, which will enable them to maintain their health and output. It is the conviction of the committee that "in the highest interest of both employers and workers proper facilities for adequate feeding arrangements should be available in or near, and should form an integral part of, the equipment of all modern factories and workshops." This policy "has abundantly justified itself from a business and commercial point of view." Marked improvement in the physical condition of workers, a reduction of sickness, less absence and broken time, less tendency to alcoholism, and increased efficiency and output, a saving of time to the workmen, greater contentment, and better midday ventilation of the workshops are some of the benefits noted.

The bulletin includes some suggestions as to dietary for munition workers, based upon a careful analysis of meals provided by canteens and hotels and the food brought by workers.

The committee urges the importance of providing opportunities for washing so that workers may be clean and tidy when they leave their employment. Bathing facilities should be provided in many industries especially where workers are exposed to great heat and excessive dust or brought into contact with poisonous materials.

The article on the value of welfare work to the employer is based upon the proposition that since the employer gives careful attention to his machinery in order to maintain output, he should give at least as much consideration to human beings, which are infinitely more complex and delicate than machines, if he would obtain a satisfactory output.

SCIENTIFIC ITEMS

We record with regret the death of Arnold Hague, a distinguished geologist of the U. S. Geological Survey, and of Herbert William Conn, professor of biology in Wesleyan University and Connecticut state bacteriologist.

At the recent meeting of the National Academy of Sciences, Dr. Charles D. Walcott, secretary of the Smithsonian Institution, was elected president, in succession to Professor William H. Welch, of the Johns Hopkins University. Professor A. A. Michelson, of the University of Chicago, was elected vice-president. The following members were elected: Edward Kasner, mathematics; Walter S. Adams, astronomy; Theodore Lyman, Walter C. Sabine, S. W. Stratton, physics; W. R. Whitney, chemistry; J. J. Carty, electrical engineering; W. F. Durand, marine engineering; H. M. Howe, metallurgy; E. O. Ulrich, geology; Robert Ridgway, ornithology; Harvey Cushing, William S. Halsted, surgery; L. H. Bailey, botany; Edward L. Thorndike, psychology.

The Council of National Defense and the National Research Council have sent six American men of science to England and France to study problems arising out of the war. Members of the party and the subjects in which they will specialize are: Dr. Joseph S. Ames, Johns Hopkins University, aeronautical conditions; Dr. Richard P. Strong, Harvard University, and Dr. Linsley R. Williams, assistant health commissioner of New York State, health and sanitation; George A. Hulett, Princeton University, chemistry of explosives; Dr. Harry Fielding Reid, Johns Hopkins University, scientific map making and photography from airplanes, and Dr. George R. Burgess, of the Federal Bureau of Standards, metals suitable for guns and rigid dirigibles.

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THE SCIENCE PRESS

Lancaster, Pa. **Garrison, N. Y.**

New York City: Sub-Station 84

SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIEN

FRIDAY, MAY 4, 1917

FRIDAY, MAY 11, 1917

Annual Subscription $5.00. **Single Numbers 15 cents.**

Published every Friday by

THE SCIENCE PRESS

LANCASTER, PA. **GARRISON, NEW YORK.**

Sub-Station 84: New York